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THE EXTERNAL GENITALIA OF THE SIMIAN PRIMATES

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FOREWORD

THE present study has as its nucleus a series of illustrations of the external genitalia of monkeys and apes drawn by Professor Max Brödel. We had hoped originally to present graphically the external genitalia of individuals of all of the principal groups of the Simiae, but limitations of time on the part of the artist precluded such an ambitious program. Rather than to fill in the gaps left in the series by calling upon other artists to complete the illustrations, it has been decided to publish Professor Brödel's drawings without any additions.

Despite the limitations in scope above referred to, the drawings as they stand contribute very material knowledge to the subject of the comparative anatomy of the external genitalia of the Simiae which it is the purpose of the present paper to outline and to discuss.

It should be added that the reproductions are actual size. The material from which the drawings of the platyrrhine monkeys were made consisted of well-preserved, embalmed bodies of selected animals killed in the wild state. This circumstance is important, for the genitalia of monkeys which have been kept in zoological gardens are frequently abnormal in the sense that the animals' reproductive life is often markedly impaired by lack of normal environment and disease, with corresponding suppression of development of the genital

tract. This affirmation can be supported by citing the high frequency of undescended testes and failure of scrotal development observed in captive males. On the other hand, the fact that dead, embalmed animals were used as subjects instead of living ones has resulted in portraying in some instances in our figures genitalia in which some distortion either by swelling or shrinkage of the tissues has taken place. Nevertheless we consider these shortcomings less detrimental to the study than the failure to secure sexually normal and active animals would have been.

In regard to macaques and chimpanzees, where breeding in captivity has now become a matter of routine, the genitalia were drawn from dead specimens whose previous health could be regarded as having been essentially normal. The illustrations of the gibbon's genitalia are from animals killed in the wild state.

The embalmed monkeys and apes used for the study were selected for the most part from the large collection of Primates assembled by Dr. A. H. Schultz who very generously placed the material at our disposal. The data on gibbons were obtained for the most part from the large collection of embalmed specimens in the U. S. National Museum which Mr. Gerrit S. Miller, Jr. kindly invited us to examine. The observations on orang utans and gorillas are derived from the collections at the Johns Hopkins Medical School, the U. S. National Museum, and the American Museum of Natural History. The latter were available for examination through the interest of Mr. Harry C. Raven.

Our descriptive observations are presented in four sections dealing with platyrrhine monkeys, catarrhine monkeys, gibbons and anthropoid apes. Due to limitation of material or time, no attempt has been made to describe systematically or to portray by drawings all known genera. Moreover, attention has been focussed in the main upon certain aspects of the external genitalia, particularly in the male the character of the scrotum and the question of the descent of the testes. Furthermore, the homologies of the scrotum and labia majora have been considered at some length with a view to achieving, if possible, a more accurate conception of the nature of the labia majora. Finally, we are recording the presence of hitherto unrecognized, extensive, specialized, sexual glands on the external genitalia of certain platyrrhine monkeys.

Other aspects of the anatomy of the external genitalia, for example, the detailed comparison of penis and clitoris, have not been considered in the present work excepting very incidentally. These structures have been the main objective of a number of previous investigators,

so that data regarding them are rather fully available (Gerhardt, 1909; De Beaux, 1917; Pocock, 1920, 1925a, b, 1927; Mijsberg, 1923; Pohl, 1928). Nevertheless a few points, as for example, the description of cornified denticles upon the penis of the spider monkeys, appear to be entirely new.

TABLE 1

Genus, Sex and Stage, and Sitting Height of Specimens Shown in Drawings

PLATYRRHINE MONKEYS:	GENUS	SEX AND STAGE	SITTING HEIGHT
Marmosets	Fig. 1. *Oedipomidas geoffroyi*	adult female	
Night monkeys	Fig. 2. *Aotus zonalis* J. H. 238	adult male	279 mm.
	Fig. 3. *Aotus zonalis* J. H. 242	adult female	278 mm.
Squirrel monkeys	Fig. 4. *Saimiri örstedii* J. H. 224	adult male	290 mm.
	Fig. 5. *Saimiri örstedii* J. H. 223	adult female	249 mm.
Capuchin monkeys	Fig. 6. *Cebus capucinus* J. H. 44	adult male	383 mm.
	Fig. 7. *Cebus capucinus* J. H. 198	adult female	299 mm.
Howling monkeys	Fig. 8. *Alouatta palliata* J. H. 18	juvenile male	253 mm.
	Fig. 9. *Alouatta palliata*	adult male	
	Fig. 10. *Alouatta palliata* J. H. 55	newborn female	189 mm.
	Fig. 11. *Alouatta palliata*	adult female	
Spider monkeys	Fig. 12. *Ateles geoffroyi* J. H. 294	male fetus	187 mm.
	Fig. 13. *Ateles geoffroyi*	female fetus	188 mm.
	Fig. 14. *Ateles geoffroyi* J. H. 221	adult male	

TABLE 1 (*Continued*)

Genus, Sex and Stage, and Sitting Height of Specimens Shown in Drawings

		GENUS	SEX AND STAGE	SITTING HEIGHT
CATARRHINE MONKEYS:				
Rhesus monkeys	Fig. 15.	*Macaca mulatta* J. H. 383	male fetus	110 mm.
	Fig. 16.	*Macaca mulatta* J. H. 171	male fetus at term	185 mm.
	Fig. 17.	*Macaca mulatta* J. H. 147	infant male	212 mm.
	Fig. 18.	*Macaca mulatta* J. H. 269	newborn female	193 mm.
HYLOBATIDAE:				
Gibbons	Fig. 19.	*Hylobates pileatus* J. H. 132A	male fetus	158 mm.
	Fig. 20.	*Hylobates cinereus* J. H. 182	juvenile male	353 mm.
	Fig. 21.	*Hylobates cinereus* J. H. 189	adult male	468 mm.
	Fig. 22.	*Hylobates agilis* J. H. P36	young adult female	349 mm.
ANTHROPOID APES:				
Chimpanzees	Fig. 23.	*Pan* spec.? J. H. 289	juvenile male	416 mm.
	Fig. 24.	*Pan* spec.? J. H. 302	female fetus	214 mm.
	Fig. 25.	*Pan* spec.? J. H. 288	juvenile female	452 mm.
	Fig. 26.	*Pan* spec.? J. H. 284	juvenile female	485 mm.
Orang utan	Fig. 27.	*Pongo pygmaeus* J. H. 373	female fetus	196 mm.
Gorilla	Fig. 28.	*Gorilla gorilla* J. H. 300	female infant	388 mm.

The sex, age, and sitting height of the specimens of which drawings were made are set forth in Table 1. The sitting heights of all specimens referred to in the paper were obtained by Dr. A. H. Schultz who gave us permission to use his measurements. In so far as it is deemed useful to give the sources of individual specimens they will be referred to by number and the initials of the respective collection. Thus: J. H., Johns Hopkins University, Department of Anatomy; N. M., U. S. National Museum; and A. M., American Museum of Natural History.

PLATYRRHINE MONKEYS

Oedipomidas geoffroyi (Marmosets)

Male. In the adult male there is a well-defined, deeply pigmented (slate colored), puckered scrotum covered with a few minute yellowish hairs. The scrotum contains descended testes. From the anterior part of the scrotum a short penis protrudes, with the glans just visible within the prepuce. There are no macroscopically visible glands on the scrotum and the two halves are separated by a furrow. Anteriorly the scrotal area extends forward as two low, pigmented ridges, separated by a furrow in the midline, over the symphysis onto the lower abdomen. These pubic ridges are visibly glandular (Fig. 30). The perineum is short and possesses a slight raphe extending to the anus. Perineum and circumanal skin are moderately pigmented. The pigmented genitalia are contrasted against the whitish, relatively unpigmented, surrounding skin which is covered by sparse yellowish hairs.

In three juvenile males, the scrotal areas are sharply defined, although the testes are undescended, and the glandular pigmented ridges extending forward from the scrotal region are scarcely in evidence—an observation which suggests that the glandular complexes develop at the time of puberty. The scrotal anlage is distinctly visible in several older fetuses which we have examined.

Female (Fig. 1). The rima pudendi is surrounded by delicate labia minora and a minute clitoris. Outside the labia minora is a large, deeply pigmented area analogous in extent to the scrotum—the labia majora. These folds which flank the external genital outlet extend forward as two conspicuous cushions over the pubis separated by a median furrow. The development of these latter areas is more conspicuous than in the male. The skin of the surrounding abdomen and thighs is unpigmented and covered by fairly sparse, long, wavy hairs

whitish to light brown in color. The labia majora are covered with sparse, extremely minute brownish hairs. Posteriorly a short raphe of unpigmented skin extends from the vulva to the anus which is surrounded by slightly pigmented epidermis.

These deeply pigmented labial folds and their forward extensions —analogous to the scrotal area in the male—are studded with minute glandular apertures which are barely visible as white dots. Microscopic study of the region has revealed (Wislocki, 1930) that the entire, deeply pigmented area of *Oedipomidas,* besides the perineum and circumanal region, is composed of glandular tissue, consisting of extensively developed sebaceous glands, situated superficially above a deeper layer of similarly large, tubular glands—the whole representing a specialized form of scent-gland (Fig. 29). This glandular apparatus of the female is much more developed than in the male. In the latter it is particularly the pubic portion of the pigmented area which is glandular although by no means so well developed as in the female. Composite scent glands, similar in nature but less extensive than those of *Oedipomidas,* have been observed in other species of marmosets (*Callithrix penicillata, Callithrix jacchus,* Wislocki, 1930). A similar pedunculated, circumgenital glandular area, less extensive than in *Oedipomidas,* has been described recently in *Hapale albicollis* (Russell and Zuckerman, 1935).

Aotus zonalis (Night Monkeys)

Male (Fig. 2). The scrotal area is well-defined in the adult and contains descended testes. The short penis surrounded by the prepuce protrudes from about the center of the scrotal skin. The scrotum is unpigmented, slightly wrinkled and covered by a few, sparse, yellowish hairs. There are no visible glands. There is no median perineal raphe; the perineum is exceedingly short and relatively hairless.

Female (Fig. 3). The rima pudendi is flanked by well-defined labia minora. The clitoris is minute and protrudes and is enfolded by a well-pronounced preputium. The labia majora are large, occupying an area almost analogous in extent and general appearance to the scrotal area of the male. They are covered by sparse, wavy, yellowish hairs and glands are not visible to the naked eye within their confines. As in the male, the perineum is exceedingly short, relatively hairless, and is elevated with a shallow median furrow.

Saimiri örstedii (Squirrel monkeys)

Male (Fig. 4). The scrotum is well developed, scarcely pendulous but nevertheless pedunculated and contains descended testes. The testes are freely movable from the scrotum into the inguinal canal and the tunica vaginalis communicates with the body cavity through an open inguinal ring. The short, slender penis, surrounded by a well-developed prepuce, protrudes from the anterior half of the scrotum. The tip of the penis is expanded into a small thick button with minute elevations upon its surface. The penis contains a small baculum. The scrotum is greyish, peppered with very obvious minute white elevations and covered by relatively sparse yellow or white hairs. Microscopic sections through the scrotal skin demonstrate it to be distinctly glandular. The perineum is rather long, possesses a slight raphe and is relatively hairless. The anus does not protrude.

Female (Fig. 5). A considerably smaller adult female shows a vulva bounded by well-defined labia minora and a short, blunt clitoris enclosed in a prepuce. The labia majora are well developed, covered by sparse hairs, and, analogous to the scrotum of the male, are composed of puckered skin which is glandular to such a degree that the labia must be regarded as a specialized glandular area (Fig. 31). The perineum is relatively shorter than in the male, and is covered by sparse yellow hairs.

In concluding, it may be added that we possess three fetuses of *Saimiri* near term, two male and one female, in which the differentiation of scrotum and labia majora can be plainly distinguished.

Cebus capucinus (Capuchin monkeys)

Male (Fig. 6). In the adult the testes are completely descended into a well-developed scrotum which, if not actually pendulous, is at least pronouncedly constricted at its base. The inguinal ring is closed in two adult specimens. The penis, which is short and stout, protrudes at the anterior margin of the scrotum. Due to swelling in the fixing fluid, the tip of the penis is considerably distorted in the figure. There is a small os penis in the midline, the urethra opening on the right. The skin of the scrotum is covered by minute nodular elevations which on section prove to be glandular. The scrotum is black against unpigmented surrounding skin, and the above-mentioned nodular elevations are less pigmented than the remainder of the scrotum. Excepting a few long, wavy, whitish hairs, the area is almost hairless.

The penis possesses a prepuce which continues as a median raphe onto the scrotum. The perineum is relatively long, well clothed with hair, and exhibits a low median raphe. The anus does not protrude.

Female (Fig. 7). The rima pudendi is relatively short, flanked laterally by delicate labia minora and anteriorly by a short, stout ventrally-cleft clitoris which possesses a well-defined preputium. The tip of the clitoris, shown in the drawing, is considerably swollen and abnormally distorted compared to living sepcimens. Dissection of a further adult female reveals a minute baculum at the tip of the clitoris. Conspicuous in the adult female is the presence of a mound of glandular tissue on either side of the vulva contiguous to the labia minora. Because of the homology of position and glandular character of these areas to the scrotum, they are accepted as being the labia majora. The glandular character of the labia majora is shown in figure 32. The perineum is rather short.

In a female fetus essentially the same features may be made out as in the adult, including two similar mounds of tissue bordering the vulva.

Alouatta palliata (Howling monkeys)

Male (Figs. 8 and 9). In the juvenile male the penis, prepuce, frenulum, and scrotal anlage may be readily made out (Fig. 8). The testes are undescended. The scrotal area resembles two wings situated laterally to the penis. The area is practically hairless excepting for a few minute hairs. Penis and preputium are unpigmented; the scrotal wings are black, with large white splotches occupying predominantly the medial aspects. The perineum is very short and the anus protrudes markedly.

In the howling monkey the testes do not descend to occupy the scrotum until close before puberty. They come to lie eventually in the adult in an extremely flaccid, pendulous scrotum which is conspicuous moreover by virtue of its being a brilliant white and practically hairless in contrast to the deeply black pigmented skin and hair of the body (Fig. 9). Small unpigmented areas may occur on the black perianal skin. There are no macroscopically visible glands present upon the genitalia.

Female (Figs. 10 and 11). The genitalia of the newborn female bear a striking resemblance to those of the juvenile male (Fig. 10). The short vulva is bordered by rosette-like labia minora and a small,

ventrally cleft clitoris. To either side of these structures are two conspicuous alae of skin—the labia majora—corresponding in position, size and shape very closely to the scrotal structures of the male. A few extremely minute hairs are visible on the labia majora. The labia minora and clitoris are unpigmented; the labia majora, similar to the scrotum, are white excepting their outer raised borders which are black.

The adult female genitalia seen in the living standing animal, from behind, present a somewhat pendulous, flattened sheet or apron of tissue about three centimeters long and two and one-half centimeters in diameter (Fig. 11). The rima pudendi is short, the labia minora and clitoris elongated, flattened and shallowly grooved in the median line. The labia majora, flanking the median structures, form the borders of the sheet. The genital outlet, including the labia minora and majora, is a brilliant white excepting the extreme borders of the labia majora which are black. The perineum is exceedingly short; the anus protrudes and is black excepting variably occurring, small, white flecks of unpigmented skin. Labia majora, perineum and circumanal tissue are very sparsely covered with hair. There are no visible glands upon the genitalia.

Ateles geoffroyi (Spider monkeys)

Male (Figs. 12 and 14). In the male fetus (Fig. 12) near term there is a conspicuous scrotum with a penis surrounded by a redundant prepuce protruding from its anterior third. Dissection reveals that the testes are already located within the scrotum. Indeed early descent of the testes is characteristic of *Ateles,* for in notes on a newborn and several juveniles, there is mention of the testes being located in the scrotum. In the fetus and newborn, however, the scrotal sacs appear to be parapenial in position, gradually in the older specimens becoming located behind the penis. The scrotum of the fetus is slightly puckered and pigmented a grey color about as deeply as the surrounding skin. The perineum is relatively long and the anus markedly protruding. There is an unpigmented raphe as well as a broad, unpigmented zone surrounding the anus and including the skin covering the ischia and reaching the base of the tail. The genitalia are very sparsely covered with hair.

In adult spider monkeys, of which we have examined many fresh specimens, the testes are descended into a semipendulous scrotum covered by skin which is markedly wrinkled, irregularly mottled

with black pigment and covered by sparse, long, wavy, yellowish or blackish hairs. Dissection of fresh adult specimens shows the testes to be freely movable, from the scrotum, through the inguinal canal up to the abdominal ring which is closed. The penis protrudes from the anterior border of the scrotum. It is a large cylindrical organ some four centimeters long and up to one and a half centimeters in diameter, with a flattened, slightly excavated end (Fig. 14). It is surrounded by a redundant prepuce which can be stripped back about four centimeters from the tip. The penis is covered by skin which towards the distal end is deeply black, but towards the base fades to grey. The penis is thickly set with small, intensely black barbs of cornified epithelium directed away from the apex (Figs. 14 and 34). These impart to the hand a sensation of touching a rasp or coarse sandpaper. There is no penis bone. The perineum is relatively long and the anus protrudes markedly.

Female (Fig. 13). The female genitalia are characterized by possessing a gigantic clitoris which has a groove along its entire ventral surface and at its base a relatively short rima pudendi. The clitoris is practically unpigmented excepting the low folds or wrinkles of skin at its base which are lightly pigmented. The wide, shallow groove on the ventral surface is also pigmented, more especially an expanded area of the groove near the tip on the ventral surface. The clitoris, excepting the groove, is clothed by sparse hairs, long and yellow near the base, especially on the dorsum, but present out to the very tip of the clitoris as minute, moderately closely set fine white hairs. The lips of the vulva are composed of similar slightly wrinkled skin, beset by minute hairs. At either side of the base of the clitoris there are folds of skin variable in distinctness in individual animals and indeed in some specimens not recognizable at all.

The homologies between male and female parts, readily interpretable in the previous groups of platyrrhines, are difficult to see at first glance in the spider monkeys. We propose, because of its texture and the presence of hair, that the skin covering the clitoris, excepting the groove on the ventral surface, is homologous to the prepuce of the male and that the naked, pigmented, oval area, not shown in the drawing, but invariably present in adult specimens, near the tip on the ventral surface, corresponds to the slightly expanded terminal portion of the penis in the male. Because of the presence of hairs on the folds immediately bordering the vulva, and surrounding the base of the

clitoris to a variable extent, we suggest that the labia minora have been incorporated into the hairless mucous membrane concealed from external view lying within the vestibule, whereas the hair-possessing folds immediately bordering the vulva are the homologues of the scrotum and hence should be regarded as the labia majora. In a dissertation, apparently long since forgotten, Fugger (1835) interpreted the parts of the female genitalia of *Ateles* practically as we are doing here.

Corresponding to the cornified barbs described on the penis, adult females possess similar but smaller barbs in the vagina which can be readily felt by the finger or demonstrated in sections (Fig. 33). In juvenile specimens it has been observed that these are not present, the vagina being thin walled and soft like chamois. Similarly we have observed the vagina of a pregnant animal, as well as one postpartum, to be devoid of these denticles. These observations suggest that the presence of these minute cornified elevations is associated with certain phases of the vaginal cycle.

CATARRHINE MONKEYS

The drawings of catarrhine monkeys are confined to the macaque. The findings in rhesus monkeys are, however, supplemented by descriptive notes on other families. In spite of the limitations of this chapter, certain noteworthy observations have been made which it is deemed of value to record.

Macaca mulatta (Rhesus monkeys)

Male (Figs. 15, 16 and 17). A well-developed scrotal anlage is present during fetal life as exemplified by Fig. 15, drawn from a fetus of 110 mm. sitting height taken from a female 2½ months pregnant. At birth there is, as a rule, a well-developed scrotum as illustrated by Fig. 16, drawn from a fetus of 185 mm. sitting height removed from the uterus at the end of gestation. The scrotal area at the time of birth in several preserved specimens appears swollen and oedematous. Out of eight late fetal macaques (ranging from 157 mm. to 227 mm. sitting height) which we have examined, four had both testes located in the scrotal sac, one had a scrotal testis on the right, an inguinal testis on the left, and three had the testes in the inguinal canal. Soon after birth and for the entire period until puberty, which occurs in the fourth or fifth year of life, the testes

are uniformly located in the inguinal canal and the scrotum is reduced to a narrow transverse fold of skin extending from groin to groin just behind the penis as illustrated in Fig. 17 of an infant male. Thus in the macaque the scrotal anlage is discernible early in fetal life, and is conspicuous up to birth, but soon afterwards appears to regress, taking the form of a simple transverse fold behind the penis until at puberty the testes gradually descend, in healthy males, to become located throughout adult life in a well-developed, semipendulous scrotum. For several years, however, at puberty the excursions of the testes are very great, shifting readily back and forth between the inguinal canals and the scrotum. Further details regarding these observations are set forth in a previous paper (Wislocki, 1933), in which it is pointed out that similar, although not identical, changes (swelling of penis and scrotum, degenerative changes in testes) around the time of birth have been described in the human reproductive tract. In man these birth changes have been ascribed to hormonal factors.

In the adult macaque the semipendulous scrotum, containing descended testes, is puckered or wrinkled and is a trace darker in color than the surrounding skin. It is relatively sparsely covered by hair which differs slightly in color from the body hair. In the newborn there is a well-defined scrotal raphe (Fig. 17) whereas in the adult it is scarcely perceptible. The perineum is excessively long in the male compared to platyrrhine monkeys. The scrotum is postpenial, although the short penis is actually located within its anterior border. The short penis possesses a well-developed prepuce, as well as glans, and contains a small penis bone causing the apex of the glans to be asymmetrical, the meatus opening slightly to the right of the midline.

Female (Fig. 18). The rima pudendi is an elongated orifice, situated between the ischial callosities, and immediately bounded by low inconspicuous folds. At its anterior end the relatively small clitoris is situated, surrounded by a delicate prepuce and without any distinct frenulum. The presence of labia majora is usually denied for catarrhine monkeys. Nevertheless, in infant female macaques, as well as in adults, there is evidence of the existence of labia majora which it is not easy to dismiss. In the newborn female macaque, as illustrated in Fig. 18, a well-defined transverse fold of skin can be observed lying between the groins anterior to the rima pudendi. This fold has bilaterally symmetrical masses of fat in it, situated near the midline. On comparing this figure with those of the male genitalia of similar

age (Fig. 17), it becomes apparent that we are dealing with a structure homologous to the scrotum. This structure practically disappears during the juvenile period, but at puberty changes strikingly reminiscent of it appear again. In healthy females at puberty there develops a sharply demarcated, thickened area of skin, pigmented, puckered, and highly colored, which extends forward over the symphysis like a triangle, with its apex at the pudendal cleft. This area, according to Hartman (1928), is swollen at the time of puberty and has underlying it, to either side of the midline, rounded masses of fat which can be rolled under the skin. These fatty masses are identical in character with similar masses in the original fold of skin present in early life. The area under discussion is moreover a specialized portion of that larger area around the genital orifice designated as the 'sexual skin.' Hartman adds that the swellings of puberty are usually confined to the region corresponding to the scrotum of the male and may well be homologized with it.

In the platyrrhine monkeys it may be observed that the length of the perineum is nearly equal in both sexes, the length of the male perineum exceeding in some species the female by only a relatively short amount. Consequently penis and clitoris and scrotum and labia majora are very similarly located in the two sexes and the homologies are strikingly apparent at a glance. In the macaque, on the other hand, the male perineum is exceedingly long, the female perineum short, thus the external male genitalia lie over the symphysis while the female genitalia occupy a field between the ischial callosities near the anus. In this spatial separation of the male and female genitalia, the labia majora appear to have become dissociated from the rima pudendi and have come to lie anterior to it in a location corresponding to the position of the scrotum in the male.

Labia majora are stated to be absent in catarrhine monkeys according to Bischoff (1879) and Weber (1928). Nevertheless, Bolk (1907) called attention to the presence of scrotum and homologous labia majora in several male and female catarrhine fetuses of undetermined genera. According to his account, the labia majora, corresponding to the scrotum, constitute a transverse ridge, underlain by fatty tissue, lying between the thighs rostral to and dissociated from the vulva. Lacking specimens of older stages, Bolk thought, however, that the labia majora disappear completely and permanently during early postnatal life.

The present observations on fetal and newborn stages of the rhesus monkey bear out the correctness of Bolk's observations. However,

study of older stages indicates that Bolk's belief that this fetal fold disappears permanently soon after birth is incorrect. Hartman's significant observations (1928) upon pubertal rhesus monkeys advances convincing evidence of the reappearance of the labial fold at this period. Our own observations on rhesus monkeys, as well as the fragmentary observations on other catarrhines, confirm Hartman's interpretation.

The acceptance of the above interpretation raises the question, however, as to what the simple, inconspicuous folds (Fig. 18) directly bounding the pudendal cleft represent. They might be construed as (1) labia minora, (2) labia majora, (3) a combination of the two preceding, or (4) an entirely new labial formation. No final answer can be given in regard to this question. Nevertheless certain considerations make the third alternative appear to be most acceptable. One might easily interpret the small hairless portion of the vulval lips, immediately adjacent to the clitoris, continuous with the prepuce, and dipping into the introitus, as labia minora. Lateral to these, in the anterior third of the cleft, but forming the actual lips of the vulva in the caudal two thirds, there are further folds, the labia majora. The arguments for such an assumption are: (1) the presence of fine hairs upon the margins of the rima, (2) indications in young rhesus monkeys, as illustrated in Fig. 18, that these folds bordering the pudendal cleft pass forward to unite with the transverse fold in the pubic region, and (3) the observation of Hartman that the triangular area of thickened skin which becomes conspicuous at puberty, besides occupying the pubic region, extends caudalward to the pudendal cleft. If this interpretation is valid, the labia majora in the rhesus monkey are represented not merely by the transverse fold, discovered by Bolk and homologous to the scrotum, but consist of additional components forming a good portion of the folds bounding the pudendal cleft. In the gibbons to be discussed in the next section, in which the morphology is similar, the evidence for such an interpretation is much more apparent.

Notes on other catarrhine monkeys

Male. Concerning the descent of the testes in other catarrhine monkeys the following notes have been collected from embalmed cadavers:

CATAL. NO. (J.H.)	SPECIES	AGE	SITTING HEIGHT	TESTES
266	*Lasiopyga albigularis*	Fetus 1 of twins	164 mm.	Beneath skin at inguinal ring
187	*Lasiopyga pygerythra*	Juvenile	296 mm.	Descended into postpenial scrotum
207	*Lasiopyga pygerythra*	Juvenile	337 mm.	Descended into postpenial scrotum
148	*Lasiopyga pygerythra*	Adult	528 mm.	Descended into large postpenial scrotum
69	*Lasiopyga rubella*	Adult	472 mm.	Descended into large postpenial scrotum
197	*Papio cynocephalus*	Juvenile	341 mm.	Undescended. Scrotal fold as in macaque
15	*Papio hamadryas*	Juvenile	338 mm.	Undescended. Scrotal fold as in macaque
149	*Papio hamadryas*	Juvenile	336 mm.	Descended into postpenial scrotal fold
25	*Papio hamadryas*	Juvenile	460 mm.	Descended into well-defined scrotum
200	*Papio papio*	Juvenile	445 mm.	Partially descended, parapenial
27	*Papio porcarius*	Sub-adult	685 mm.	Descended but postpenial Scrotum inconspicuous
209	*Erythrocebus patas*	Juvenile	372 mm.	Descended but postpenial Scrotum indistinct
193	*Cercocebus aethiops*	Adult	461 mm.	Descended into small parapenial folds
175	*Pygathrix entellus*	Juvenile	478 mm.	Descended
180	*Pygathrix cristata*	Juvenile	510 mm.	Descended into postpenial scrotal fold

These notes on additional catarrhine monkeys show that in adults and late juveniles, similar to the macaque, the testes are descended into a scrotum of varying degrees of distinctness. Further descriptive notations indicate that the relationships of testes, scrotum and penis are in several important respects similar or identical to those described in the rhesus monkey. The following notes make this clear. A fetal *L. albigularis* (266) exhibits a relatively hairless scrotal anlage consisting of a transverse fold of skin immediately behind the penis extending to the groins. In four juvenile and adult specimens of *Lasiopyga* the scrotum is well developed, highly colored, postpenial, nearly hairless, and the scrotal area is connected by characteristic folds to the groins.

In the baboons a transverse, postpenial, relatively hairless, scrotal fold, practically identical with that observed in the macaque, is highly characteristic. The absence of descended testes in the two youngest of the baboons of the series suggests that as in the macaque the testes descended late, and that in the interim the scrotum is represented by a transverse fold reaching from thigh to thigh. In these two young animals the testes can be palpated beneath the skin in the inguinal region. In the two older *P. hamadryas* the testes have entered the scrotal fold leading to the formation of a well-developed scrotum covered by loose puckered skin. In a juvenile *P. papio* the testes have descended so as to produce two parapenial elevations, but they have not entered the scrotal fold which lies just posterior to the penis. Notations on a single juvenile adult *P. porcarius* record that the testes are in a postpenial position, but do not occupy the transverse fold of scrotal skin. These observations suggest that, as in the rhesus monkeys, scrotal descent is late, and that the location of the testes, due to their mobility, is subject to considerable variation.

In an adult *Cercocebus aethiops* the testes are descended and lie in a parapenial position within a small scrotum which is continuous laterally as folds of skin reaching to the groins. In a juvenile *Pygathrix cristata* the testes have descended into a sparsely haired, puckered scrotum spread between the thighs.

Similarly to the macaque, the male perineum is extremely long in all of these callosity-bearing catarrhine monkeys.

Female. In the females of the catarrhine species which we have examined the rima pudendi lies close to the anus, between the ischial callosities.

The folds bordering the opening of the vulva are relatively simple and inconspicuous compared to the platyrrhine monkeys. In the preceding section on the macaque evidence was adduced to show that the labia majora, the homologue of the scrotum, had apparently come to lie as a transverse band anterior to and dissociated from the vulva. In keeping with this interpretation, we have notes on a fetus of *Pygathrix germaini* near term (sitting height 177 mm.) in which anterior to and dissociated from the vulva there is a transverse fold of loose skin associated with bilateral subcutaneous mounds of fat analogous to those observed in the rhesus monkey.

In a juvenile *Papio papio* (sitting height 450 mm.) there appear to be two low ridges extending forward from the vulva onto the sym-

physis. In an adult *Nasalis larvatus* (sitting height 524 mm.) similar low longitudinal ridges are present. In regard to the vulva, examination of a fetal specimen of *Pygathrix germaini,* of a juvenile *Lasiopyga pygerythra,* and of an adult *Erythrocebus patas* shows that the folds, bordering the margins of the rima pudendi, are dotted with sparse hairs.

GIBBONS

Male (Figs. 19, 20 and 21). Only very fragmentary descriptions of the external genitalia of the various groups of gibbons exist. We have had an opportunity to observe the embalmed specimens in the rather extensive collections of the Anatomical Department of the Johns Hopkins University and of the U. S. National Museum. From this study the following notes have been assembled concerning the scrotum and descent of the testes in gibbons.

COLLECTION	SPECIES	AGE	SITTING HEIGHT	TESTES
Harvard U.	*H. concolor*	Fetus	145 mm.	Distinct parapenial scrotum Testes undescended
N.M. 145643	*H. concolor*	Juvenile	275 mm.	Scrotum parapenial. Testes undescended
N.M. 151976	*H. concolor*	Juvenile	344 mm.	Scrotum parapenial. Testes undescended
J.H. 271	*H. lar*	Juvenile	288 mm.	Testes in prepenial to parapenial scrotum
N.M. 254457	*H. lar*	Adult		Testes in prepenial to parapenial scrotum
J.H. 204	*H. cinereus*	Juvenile	328 mm.	Tests in parapenial scrotum
J.H. 182	*H. cinereus*	Juvenile	353 mm.	Tests in parapenial scrotum
J.H. 189	*H. cinereus*	Adult	468 mm.	Tests in parapenial scrotum
J.H. 132A	*H. pileatus*	Fetus	158 mm.	Distinct parapenial scrotum Testes undescended
J.H. 121A	*H. pileatus*	Infant	198 mm.	Distinct parapenial scrotum Testes undescended
N.M. 257681	*H. agilis*	Juvenile	365 mm.	Testes in prepenial scrotum
N.M. 114510	*H. agilis*	Adult		Testes in prepenial to parapenial scrotum
N.M. 127683	*H. klossi*	Infant	211 mm.	Testes descended into prepenial to parapenial scrotum

These groups of gibbons appear to be essentially alike in regard to the major features of scrotal development in contrast to the two groups (*H. leucogenys* and *S. syndactylus*) which will be presented

below. The distinctive features of the above groups can be summarized as follows: the data indicate that the testes do not descend into the scrotum at birth but at some time much later, in the juvenile period. In relation to total body size the testes, even in the adult, give the impression of being small (Fig. 21). A differentiated scrotal area is always recognizable and is indeed conspicuous in fetal life (Fig. 19) and early postnatal life. Figures 20 and 21, of a juvenile and of an adult *H. cinereus*, indicate that the extensive scrotal elevations in the juvenile gibbon, extending from anus to symphysis, become reduced in the adult to relatively small areas, lying to either side of the penis, or somewhat anterior to it, in a position that can be referred to as parapenial or prepenial. The scrotal skin is as a rule darker in color than the surrounding body skin and the scrotum is relatively hairless compared to the body, although the hair is as a rule longer, darker and more wavy than elsewhere. There is an extremely long perineum with a conspicuous raphe.

In contrast to the above, *H. leucogenys* differs materially.

N.M. 256087	*H. leucogenys*	Infant	185 mm.	Distinct postpenial scrotum. Testes undescended
N.M. 256088	*H. leucogenys*	Juvenile	314 mm.	Distinct postpenial scrotum. Testes undescended
N.M. 256439	*H. leucogenys*	Adult	462 mm.	Testes in postpenial, semipendulous scrotum

H. leucogenys possesses a well-developed, postpenial scrotum, larger that in the preceding, and characterizable as semipendulous. In contrast to the previous groups, the scrotal area in the juvenile and adult specimens is concealed by extremely dense, long, dark hair which can be aptly compared to a beard. The perineum is densely haired and a raphe is absent or inconspicuous.

Symphalangus syndactylus has been examined in three specimens:

Amsterdam	*S. syndactylus*	Fetus	168 mm.	Conspicuous postpenial scrotum. Testes undescended
N.M. 255980	*S. syndactylus*	Juvenile	423 mm.	Small postpenial scrotum. Testes undescended
N.M. 258843	*S. syndactylus*	Adult	511 mm.	Testes descended into small postpenial scrotum

The data for *Symphalangus* indicate that the scrotum in postnatal life is small and postpenial, with a tendency to be divided into separate scrotal halves. The testes descend into the scrotum late and remain relatively small and close to the body wall. The scrotum is concealed by a dense beard of black hair which is longer than the surrounding body hair. The perineum is clothed with hair and a raphe is only moderately represented.

The above data are more informative, but agree in the main with the brief notes of Miller (1933). In regard to *Symphalangus* Miller says merely "testicles descend partly below base of penis." Mijsberg (1923) describes a *"Siamanga syndactylus,"* alternately referring to it as *"Hylobates"*, in which the scrotum was well developed, pendulous and postpenial. His description is more like our *H. leucogenys*, a matter which cannot be determined because of the ambiguity attaching to the identification of his specimen. Selenka (1903) presents incidentally a drawing of the genitalia of a fetus (l. c. Fig. 45) of *S. syndactylus* in which the scrotum is well-developed and clearly postpenial; in two sketches of fetuses of *H. concolor* (l. c. Figs. 41 and 48), on the contrary, the scrotum is separated into parapenial halves.

In view of the present observations, the majority of statements made in the literature are obviously incorrect. Kohlbrugge (1892) says briefly that the genus Hylobates is characterized by two swellings at the symphysis which contain testicles but are not differentiated from the surrounding skin. Sonntag (1924) states that the scrotum is absent in the gibbons, but the testicles are covered by folds of skin of the anterior abdominal wall. Pocock (1925) dismisses the subject by the remark that there is no trace of a scrotum in *Hylobates*. He qualifies this by saying that at most the testes descend to the inguinal region to form a bilobed swelling in front of the base of the penis. Wood Jones (1929) does not materially clarify the matter by saying (p. 253) that the most notable feature concerning the external genitalia of the male gibbon is the failure of the development of a typical pendulous scrotum. The genital glands, he continues, lie beneath the skin of the inginual region, but are not received into definite pendulous scrotal pouches. The present observations show that in regard to scrotal character *H. leucogenys* and *S. syndactylus* differ from the remainder of the gibbons. In *H. leucogenys* the scrotum is postpenial and semipendulous; in *S. syndactylus* it is postpenial but close to the body wall and markedly divided; in the remaining gibbons it is composed of independent components lying to either side of or anterior to the penis.

Female (Fig. 22). A young adult *H. agilis* has been chosen for illustration. As in the catarrhines, the rima pudendi lies posteriorly, close to the anus, between the callosities. There is a prominent, ventrally cleft clitoris, surrounded by a prepuce. The vulva is bordered by low folds, which are continuous with the prepuce. Lateral to these and bordering the posterior half of the rima are two further folds. Anterior to the vulva, towards the symphysis, there are two low cushions of skin, covering fatty tisue, one to either side of the midline.

We shall not give a complete description of each of the female gibbons which we have examined, but will turn our attention solely to the question of whether they possess labia majora. Regarding the designations of the vulval folds in the gibbons there is great uncertainty at the present time.

Bischoff (1877, 1880) and Sonntag (1924) state that there are no labia majora in the gibbons. Pocock (1925) remarks merely that in *Hylobates* the upper orifice of the vagina and the lower orifice of the urethra are flanked by normal labia; he adds moreover that there are a few hairs on the labia of the vulva. Wood Jones (1929) says that the outer genital folds are not recognizable. Schultz (1927), however, states that the labia majora in the *Hylobatidae* are well developed in the fetus and are retained as comparatively large structures throughout postnatal growth, when the labia minora are becoming smaller. As proof Schultz presents drawings of two fetuses of *H. mülleri* of 100 and 161 mm. sitting height respectively, as well as a view of the same nearly full grown *H. agilis* which is illustrated in the present paper. It is beyond dispute that in these two fetuses, which we have also had an opportunity to examine, there are labial folds, covered with fine hair extending from the region of the symphysis, around the clitoris and labia minora bordering the vulva, to the perineum. These folds in the fetus Schultz identifies as labia majora, and we believe rightly so, because their extent coincides very exactly with that of the scrotal area as exemplified in the young male shown in Fig. 20. Deniker (1885) also shows an illustration of a gibbon fetus in which labia majora extend forward onto the symphysis in almost identical form to that portrayed by Schultz.

It is obvious from a series of juvenile and adult females of various species of gibbons which we have examined in the collections of the Johns Hopkins University and the U. S. National Museum that the fetal labia majora become somewhat obliterated in postnatal life. Schultz regards the two folds bordering the rectal half of the vulval orifice in the adult (Fig. 22) as the sole remains of the labia majora, chiefly because these folds are covered with sparse hair. Schultz has overlooked the two elevations of fatty tissue rostral to the clitoris as exemplified in our drawing. They are not very conspicuous in the specimen here portrayed, but from other animals, examined in the collection of the U. S. National Museum, it becomes quite evident that some specimens possess in postnatal and even in adult life a fold on either side of the clitoris which extends rostrally towards the symphysis. Indeed in an adult specimen of *H. lar* (N. M. 255903) these folds rostral to the clitoris are darker and possess longer, blacker hair than the surrounding skin. In a miniature way they resemble the adult scrotum in regard to distribution and character of the hair. In two specimens of *H. concolor* (N. M. 154411 and 255967) the hair on these elevations is also outspokenly darker than in the neighborhood. In

a further specimen of *H. agilis* (infant N. M. 113419) and in two *H. klossi* (infant N. M. 121693, juvenile N. M. 121682) folds are present which extend toward the symphysis from the sides of the clitoris. In an adult *H. leucogenys* (N. M. 256436) lateral folds are conspicuous extending from the anus forward well onto the symphysis. On the basis of their extent and character these folds occurring in the female gibbons are regarded as labia majora and as homologous to the scrotum of the male. They coincide most exactly with the scrotal swellings of the fetal or infant male (Figs. 20 and 21) which extend from the neighborhood of the anus well forward onto the symphysis. From our study we believe we are justified in concluding that female gibbons throughout life possess labia majora which in extent coincide with the position of the scrotum in young males; consequently the labia majora extend well rostrally beyond the margins of the vulva and the clitoris. Thus in the gibbons, also, it appears, similarly as in the catarrhine monkeys, that components of the labia majora have become dissociated from the rima pudendi, lying rostral to the clitoris.

ANTHROPOID APES

Chimpanzee

Male (Fig. 23). The chimpanzee has a well-defined scrotal area in fetal life and a well-developed scrotal sac containing descended testes in postnatal life. In healthy adult chimpanzees the scrotum becomes semipendulous. With Dr. A. H. Schultz we have collected data which are presented in the accompanying table (Table 2) to show that the testes descend permanently as a rule around the time of birth. Indeed, in a normal well-preserved chimpanzee fetus of 193 mm. sitting height the small testes are completely descended into a well-defined scrotum. This fetus corresponds to a human one of the seventh or eighth lunar month. Similarly in a chimpanzee prematurely born with a sitting height of 240 mm., Schultz has noted the presence of the testes in a scrotum which is quite large. In contrast to our findings, Mijsberg (1923) reports the testes as being at all periods incompletely descended in chimpanzees.

As may be observed from Figure 23, the scrotum is postpenial, exhibits a mesial raphe and is separated from the anus by a perineum of moderate length which is well clothed by hair. The penis is relatively long and slender with a slightly thickened apex which by several writers has been denied the rank of a glans.

TABLE 2

Descent of Testes in Chimpanzee

SPECIMEN	SITTING HEIGHT	
Pan paniscus Am. Mus. Nat. Hist.	193 mm. (fetus)	Testes in scrotum
Yerkes' specimen	240 mm. (premature)	Testes in scrotum
Phil. Zool. Garden	350 mm. (7 lbs.) known age 6½ mos.	Testes in scrotum
McGregor Coll.	363 mm.	Testes in scrotum
Hopkins 262	384 mm. (8.7 lbs.)	Testes in scrotum
Hopkins 260	389 mm. (10.6 lbs.)	Testes in canal; sick animal
Hopkins 315	416 mm.	Testes in scrotum
McGregor Coll.	429 mm.	Testes in scrotum
Hopkins 191	438 mm.	Testes in scrotum
McGregor Coll.	439 mm.	Testes in scrotum
Hopkins 217	447 mm.	Testes low in canal
Hopkins 215	463 mm. (19.5 lbs.)	Testes in scrotum
Hopkins 162	492 mm.	Testes in scrotum
Hopkins 297	477 mm.	Testes in scrotum
Hopkins 296	496 mm.	Testes in scrotum
Hopkins 372	510 mm.	Testes in canal; sick animal
Dayton Nov. 1927	513 mm. (29.5 lbs.)	Testes in scrotum
Hopkins 290	515 mm.	Testes in scrotum
Hopkins 214	543 mm.	Testes in canal

Female (Figs. 24, 25 and 26). The genitalia of the female chimpanzee are characterized by the presence of a relatively short rima pudendi surrounded by rather conspicuous puckered labia minora which are continuous with a somewhat drawn out flattened clitoris enfolded by a distinct prepuce (Fig. 26).

It has been subject to dispute whether or not the chimpanzee possesses labia majora. Bischoff (1879) and Friedenthal (1910) have denied their existence. On the other hand, Hoffmann (1878), Symington (1889), Sperino (1897) and Sonntag (1923) examined chimpanzees which presented evidence of labia majora. Sonntag (1923, p. 268) shows a convincing, labelled photograph of them with remarks to the effect that the mons veneris is slight and has a few sparse hairs, and the labia majora are represented by slight elevations of the skin over thickenings of the subcutaneous tissue. Schultz (1927) has summarized the present status of our knowledge of the labia majora in the great apes and man. He says that it

is certain that these structures are laid down in fetal life, but, whereas in man they persist throughout growth, in the anthropoids they undergo a variable degree of ontogenetic reduction, sooner or later leading to complete disappearance.

The present observations upon the chimpanzee are in essential agreement with the observations of Sonntag and the conclusions of Schultz.

The illustrations present, more completely than has been done heretofore, visible evidence of the nature of the labia majora. Figure 24 shows the genitalia of a chimpanzee near term. Around the genital orifice and the bordering labia minora, which are arranged in the form of a rosette, is a relatively hairless fatty cushion, extending from symphysis to anus. In the juvenile chimpanzee the labia majora may be present in the form of fatty cushions bordering the labia minora and extending forward toward the symphysis as two elevations separated by a furrow in the midline (Fig. 26). It is apparent that these cushions occupy a position analogous to the scrotum in the male (Fig. 23). The degree of development of the labia majora is, however, subject to considerable individual variation. Figure 25 illustrates another juvenile chimpanzee in which labia majora are not recognizable. To what extent the labia majora manifest themselves in fully grown females has not been recorded.[1]

Orang utan

Male. According to brief statements by Fick (1895), Pousargues (1895) and Friedenthal (1910), the testes of the orang utan are relatively small and lie in a recognizable scrotum, postpenially, close to the body wall. The penis is short and slender. There is no glans and a frenulum is absent from the prepuce. Friedenthal presents a colored illustration of an orang designated as nearly grown. The compact scrotum is hairless and purple, and lies close to the body wall. The testicles appear to be descended.

The youngest specimen which we have examined is an infant *Pongo pygmaeus,* (N. M. 153826, sitting height 300 mm.). The whole region between the thighs is practically hairless. The scrota consist of two separate, wrinkled, pigmented, small areas situated behind the penis and separated by a stout median raphe extending from penis to anus. The small, flattened testes are situated in low folds of skin just

[1]Zuckerman was prompted to take up the matter, and in a paper with Fulton (*Jour. Anat.*, 1934, vol. 69, p. 44) adduces evidence of the presence of labia majora in a nearly full-grown specimen.

anterior to the borders of the scrotal areas and lateral to the penis. The elevations of skin containing the partially descended testes are symmetrically placed on either side of the penis and taper obliquely upward to the inguinal region.

The next oldest specimen observed is a juvenile *Pongo pygmaeus* (N. M. 254456, sitting height approx. 550 mm.). In this specimen the postpenial scrotum is darker than the surrounding skin and almost hairless. The testes are completely descended and lie close to the body. The scrotum consists of two pigmented halves situated postpenially and separated by a relatively unpigmented raphe. The genitalia are relatively small; the penis is very short, and the perineum long.

Two older specimens (A. M. 1200, sitting height 687 mm., and A. M. 627, sitting height 770 mm.) are almost alike. The relatively small scrotum consists of an almost hairless, deeply pigmented fold, situated postpenially, close to the base of the penis. The surrounding skin is clothed by long hair. The scrotum is compact and causes the scrotal skin to bulge without, however, being at all pendulous. A slight median raphe exists between the two halves. The testes are small, fully descended, and upon palpation are found to be quite mobile. The wall of the scrotum, as well as the subcutaneous tissue around the base of the penis and in the inguinal region, is markedly adipose.

It is obvious from this account of the male orang utan that testes and scrotum are relatively small. Nevertheless, the scrotal areas are differentiated at birth and the testes appear to descend permanently at that time.

The specimens observed were all of *Pongo pygmaeus,* the Bornean orang, with one exception, a specimen of *Pongo abeli,* the Sumatran form (N. M. 259188, sitting height 625 mm.). This juvenile animal differs materially from the preceding. The testes lie in suprapubic position and are extremely small. Pigmented scrotal areas are not visible, barring two slight unpigmented folds on either side of the base of the short, stout penis. These findings in one specimen indicate the need of examination of further Sumatran orangs to see whether essential differences in the genitalia of the two species really exist.

Female (Fig. 27). For the orang utan an illustration is presented of the genitalia of a female fetus (sitting height 196 mm.). Compared with the chimpanzee fetus (Fig. 24), one sees a small, almost circular rima pudendi flanked by protruding, puckered labia minora and exhibiting a small, protruding clitoris. Resembling the chimpanzee,

there are crescentic cushions of fatty tissue on each side of the vulva which we believe are the labia majora. Just anterior to the clitoris, on either side, these cushions exhibit superimposed, rounded hillocks.

We have examined also a newborn (N. M. 153825; sitting height 264 mm.) in which the puckered, rosette-like configuration of the labia minora is identical with the fetal specimen. Symmetrically placed and extending forward on each side from the border of the labium minus is a cushion of skin which traverses the pubic region to taper imperceptibly into the tissue of the groin. These structures are homologous in position to the scrotal areas and the attendant folds of skin extending to the groin described in the infant male in the preceding section.

In two female adults examined (Coll. Amer. Museum) there is a sparsely haired field flanking the vulva and extending forward over the pubic region. There is, however, little to be seen in this field of well-defined elevations. In a third adult specimen, however, pronounced, elongated cushions, containing fatty tissue, extend forward from the pudendal region, strikingly resembling the fatty pads present in the chimpanzee shown in Figure 26. The degree to which these labial cushions are visible in late postnatal stages is probably subject to marked individual variation.

Bischoff (1879), Klaatsch (1892), Fischer (1898), and Friedenthal (1910) report finding traces of labia majora in the orang. From Bischoff's rather obscure sketch of the genitalia of a half-grown specimen (Plate V, Fig. 7), one is left in considerable uncertainty as to the proper identification of the structures; Klaatsch says merely that he found labia majora in a young orang. Fischer presents a figure of a juvenile orang in which the parts labelled labia majora coincide with the present interpretation, although there are other structures in his specimen, such as a transverse fold on either side, uniting labia minora with the majora, which have no counterpart in the present specimens. Friedenthal gives two colored figures of the genitalia of young orangs in which folds identical with the ones described in our infant specimen are visible. He does not refer to them as labia majora but calls attention to their homology with similar folds occurring in the pubic region in the human newborn.

In summary it may be stated that female orangs have variably conspicuous protuberances of fatty tissue, the labia majora, lying for the most part anterior to the pudendal cleft, in a position homologous to the divided scrotal area of the infant male.

Gorilla

Male. The youngest gorilla fetus on record is a male (88.5 mm. sitting height) described by Duckworth (1898) regarding which he says briefly: "The external genitalia are represented by an almost sessile penis, a trace of glans being just distinguishable; the organ is still grooved along its lower surface. Testes are impalpable." No mention of scrotum is made. Concerning the next oldest male gorilla fetus (170 mm. sitting height) in the collection of the Institute of Anatomy at Amsterdam, Dr. W. L. Straus, Jr., who had an opportunity to examine it, has made the following notes: "The penis is continued caudalwards with a distinct median raphe extending as far as the anus. Just at the base of the penis are two distinct scrotal swellings, but within these swellings there are no palpable testes."

During early postnatal and juvenile life the scrotum is scarcely evident. Ehlers (1881), referring to an animal (*G. gorilla,* sitting height 114 mm.) of probably one year or less of age, says that there is a median raphe from prepuce to anus and practically no visible scrotum.

The genitalia of a mountain gorilla (*G. beringei,* sitting height 589 mm.) which we have examined (Coll. National Museum), weighing 40 lbs. at death and supposed to be about two years and eight months of age, show almost no visible scrotum. Bilaterally situated immediately behind the penis, which is rather stout and about two centimeters long, there are scarcely distinguishable scrotal elevations which are relatively hairless. Dissection of the region shows a thick layer of fat beneath the scrotal skin. Further examination reveals, within the layer of fat, minute, descended testes which are parapenial to postpenial in position. Mere observation of the scrotum, or palpation even, would not suffice to find the small testes, situated within the pad of fat, and would doubtlessly have led to the erroneous conclusion that the testes were undescended. The external appearance of this specimen is almost identical with a sketch of the scrotum presented by Klaatsch (1890) designated as of a young gorilla.

We have some interesting notes made by Dr. C. R. Carpenter regarding the genitalia of two male mountain gorillas living in the San Diego Zoological Garden. These animals were estimated at the time of examination to have been seven and eight years old respectively. Dr. Carpenter reports that the genitalia of these adolescent gorillas were very small and covered with rather dense hair. All that was visible of the genitalia were two indistinct light areas in the crotch, which proved upon manual palpation to be the scrotum containing descended testes. Indeed, the genitalia were so much concealed that it was only upon palpation that all doubt regarding the sex of the animals was removed. The scrotum consisted of a postpenial bulge of skin which

was tightly drawn over the testes. Although it was difficult to estimate the size of the gonads, they were approximately two and a half centimeters in length, ovoid in shape and about one and a quarter centimeters in diameter in largest breadth. The relaxed penis, which was concealed by a tuft of hair, could be palpated at the anterior border of the scrotum. The penis was short, about the diameter of a lead pencil, and was almost completely contained within a loose sheath of skin.

For comparison with the infant and juvenile gorillas, we have examined an adult *G. beringei* killed by H. C. Raven (A. M. 1453, sitting height 1030 mm.). The animal is a full-grown specimen of splendid physique. Examination reveals that the external genitalia are exceedingly small in proportion to body weight. The genitalia are partially concealed by abundant, long, wavy hair. The penis is relatively short; the oval glans protrudes from the prepuce. The small scrotum is placed immediately behind the base of the penis forming a bilobed sac close to the body wall. The testicles are also surprisingly small compared to the size and weight of the animal. The right scrotal sac protrudes much more than the left and between the two halves there is a deep incisura which almost separates them.

It is clear from the foregoing observations that the scrotum of the gorilla is extremely poorly developed, even in the adult not becoming pendulous. Moreover, the gonads are at all periods relatively small. The relative lack of differentiation of the scrotum and small size of the testes might lead one to believe that the testes descended late. Nevertheless in an infant gorilla of two years, although palpation failed to reveal them, testes were found beneath the scrotal areas upon dissection. Notes regarding the descent of the testes are needed on further specimens, but this one observation indicates that, as in the chimpanzee and orang utan, in the gorilla, also, the testes descend at or soon after birth.

Female (Fig. 28). For comparison with the fetal chimpanzee and orang utan, a drawing is presented of the genitalia of a female infant gorilla (*G. gorilla,* sitting height 388 mm.). The vulva is surrounded by conspicuous labial folds, the lips of which, contiguous to the vulval orifice, are puckered, hairless and unpigmented. External to the small unpigmented center, the labial folds are deeply pigmented and exhibit scattered, minute hairs. There is a conspicuous, protruding, ventrally cleft clitoris surrounded by a well-developed prepuce, but

without a frenulum. The anus protrudes markedly and is separated from the vulva by a well-defined perineum with a clearly visible raphe.

The heavy folds almost encircling the rima pudendi and continuous with the prepuce of the clitoris we interpret as labia minora basing this belief on the similarity of appearance in orang, chimpanzee and gorilla. According to this interpretation all of these three animals have rather large labia minora and protruding clitoris. The labia majora, as in the chimpanzee and orang, consist in the gorilla also of fatty cushions situated on either side of the medial structures and extending from the symphysis to the perineum. The exact limits of these adipose labial pads are not easily visible, nor can they be readily defined, but they protrude most prominently at the level of the clitoris and the vulval orifice.

Examination of two older infant gorillas of 359 and 365 mm. sitting height (*G. gorilla,* A. M. 1458 and 1105) substantiates the present interpretation. Centrally, surrounding a short pudendal cleft, there are conspicuous rosette-like folds, the labia minora. Lateral and anterior to the median circular field there are bilaterally represented fatty ridges, the labia majora. This interpretation coincides well not only with chimpanzee and orang but with the appearance of late fetal human stages (two excellent drawings of which at the sixth and eighth months are presented by Didusch (Koff, 1933), where the labia majora are similarly composed of conspicuous fatty cushions extending from symphysis to perineum).

In a young fetus of gorilla (sitting height 88 mm.) Schultz pictures two folds, covered with minute hairs bordering the rima pudendi, as the labia majora. In spite of the resemblance of these folds to the labio-scrotal folds in a human fetus of equivalent age, which is also shown in Schultz's paper we are somewhat doubtful of the interpreted homology. As shown in text-figure 2 of Spaulding (1921), the human labio-scrotal folds do not unite cephalad to the clitoris, as suggested in Schultz's sketch of gorilla, but pass forward like the limbs of a horseshoe into the pubic region. In the gorilla fetus depicted, the alleged labia majora are definitely attached laterally to the clitoris, interrupting any assumed phallic groove, and the folds, moreover, clearly encircle the clitoris. Our interpretation, based upon the observation of the later stages of gorilla and comparison with the other apes, as well as by reference to the illustrations of human fetuses presented by Koff, leads us to the belief that the folds in question are labia minora

and that the labio-scrotal elevations—to be sought lateral to these—are absent or too poorly defined at this stage to attract notice.

In Deniker's (1885) gorilla fetus (135 mm.) he recognizes inner labia minora and outer labia majora. Bischoff (1879) failed to identify the labia majora in three young animals, while Gerhardt (1906) found no trace of the structures in an adult.

The present interpretation derived from comparison of the three great apes and man suggests that labia minora and clitoris are relatively large, somewhat protruding and approximately circular in outline in the apes. The labia majora, lateral to these, are, on the other hand, relatively inconspicuous elevations of adipose character, variable in extent and visibility in individual specimens and diminishing, as far as can be ascertained, with age. In the human the labia majora are more conspicuous and when in their normal position conceal for the most part the slender medially placed labia minora which lie more internally and are not everted as in the apes.

DISCUSSION AND SUMMARY

Scrotal representation and descent of the testes in the Simiae.

A summary of our observations on this subject is deemed important because of the statements (1) of Klaatsch (1890, 1892) that catarrhine monkeys possess no scrotum whatsoever, but that a scrotum may be present in some platyrrhines (*Hapale, Cebus*); (2) of Bolk (1907) that a scrotum is present in the fetal stages of catarrhines but decreases or disappears with age; (3) of Mijsberg (1922) that *Ateles, Macacus, Semmopithecus* and *Cynocephalus* have no scrotum whatsoever, whereas *Oedipomidas, Cebus, Crysothrix,* chimpanzee and orang utan have a scrotal area which does not contain descended testes; and (4) of Weber (1928, p. 781) to the effect that a scrotal anlage is usually absent in catarrhines, whereas it occurs now and then in platyrrhines.

The present observations are considerably at variance with the above conclusions. Our findings may be summarized as follows:

1. A scrotal anlage is distinctly present in late fetal stages of all Simiae which have been carefully examined. Our data cover *Oedipomidas, Saimiri, Cebus, Alouatta, Ateles, Macaca, Hylobates, Pan, Pongo* and *Gorilla.*

2. The scrotum persists throughout life. For a part of the juvenile period, however, in many catarrhine monkeys, in which the testes do not descend into the scrotum until late, the scrotum may be relatively inconspicuous. When the testes finally descend completely, at or before puberty, the scrotum becomes enlarged.

3. The testes invariably descend completely into the scrotum in healthy adult monkeys and apes.

4. The time of descent of the testes varies in different species. In man and the chimpanzee permanent descent usually occurs at birth. The fragmentary data for gorilla and orang indicate that in these apes descent also takes place at birth or during the period of infancy. In the entire groups of platyrrhine and catarrhine monkeys, as well as gibbons, the data suggest that permanent descent occurs some time in the juvenile period. For the macaque the time of permanent descent has been satisfactorily established as at puberty between the fourth and fifth years of age. The spider monkey appears to form an exception amongst the platyrrhines, descent occuring during infancy.

5. The topography of the adult scrotum varies considerably. In the majority of monkeys and apes it lies close to the body or becomes at most slightly pedunculated. In man and in the howling monkeys the adult scrotum attains the most pendulous character of all. The location of the scrotum is also subject to variation. It lies postpenial in all groups excepting the majority of gibbons in which the scrotum is represented by bilateral areas in a parapenial or partly prepenial position. *H. leucogenys* and *S. syndactylus* form exceptions amongst the gibbons in which the scrotum occupies a postpenial position. In gibbons, compared to other groups of monkeys, scrotum and testes are relatively small in comparison to body weight. In gorilla and orang utan, also, testes and scrotum are exceedingly small in contrast to total body weight.

6. Birth changes in the genitalia, similar to those described for man, have been observed in the rhesus monkey (Wislocki, 1933). These changes consist of swelling or oedema of the scrotum and oftimes a temporary descensus of the testes immediately at or before the time of birth. Throughout the juvenile period the scrotum is represented merely by a transverse, postpenial fold. Indications of a similar fold have been seen in other catarrhine monkeys. With permanent descent of the testes at puberty in the rhesus monkey, this scrotal fold enlarges to receive the testicles and to become a typically protruding scrotum.

7. Our findings that the scrotum is fully present and that the testes are descended in all healthy adult monkeys and apes are at variance with the observations of Bolk (1907) and Mijsberg (1921). The former concludes that the scrotum of catarrhine monkeys undergoes permanent postnatal regression and upon this belief he bases the phylogenetic reasoning that the ancestors of the catarrhine monkeys had more fully developed scrota than the present representatives. Mijsberg postulates that the condition of descended testes with fully developed scrotum, as in man, is primitive, whereas complete or partial absence of scrotum and incompletely descended testes, as occurs according to him in the majority of catarrhine monkeys and anthropoid apes, is more progressive, constituting a form of evolutionary reduction of the scrotum accompanied by a permanent ascensus of previously descended testes. Since our observations do not substantiate any of the above premises, we cannot accept either Bolk's or Mijsberg's phylogenetic conclusions.

The labia majora: their representation in the Simiae

The question of the existence and degree of representation of labia majora and labia minora in the various groups of the Simiae is a complex one to solve. The answer depends to a considerable degree upon the definition given to the terms which are in their origins descriptive of the human genitalia. The labia majora in the human are described as two rounded masses on either side of the vulva, composed of fatty tissue. They are continuous with the mons veneris above and fade away into the perineum posteriorly, forming, according to some, the posterior border of the rima pudendi (posterior commissure).[2] The so-called outer or lateral surface of each labium

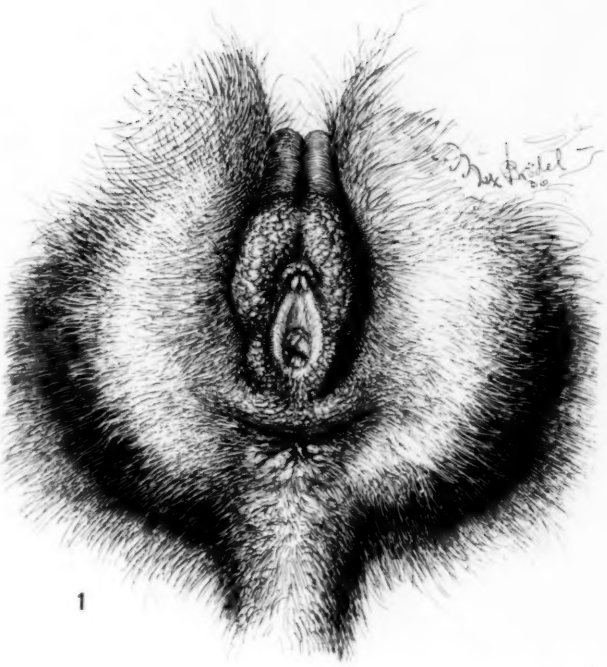
[2]The mons veneris is defined in man as a pad of fatty tissue overlying the symphysis in the female. In the platyrrhine monkeys there is not a pronounced enough deposit of adipose tissue at this particular site to justify the use of the term. In the rhesus monkey, as an example of conditions in the catarrhines, the skin overlying the symphysis is involved in the formation of the transverse labial fold, homologous to the scrotum of the male. The term seems superfluous here also. In the great apes, especially during early life, when the labia majora are extensive and bear a striking similarity to the human, that portion of the labia majora extending forward onto the symphysis can well be homologized with the human mons veneris. Since, however, the labia majora undergo marked ontogenetic reduction in the apes, in some individuals amounting to practically total disappearance, a mons veneris is at best less easily distinguishable than in the human.

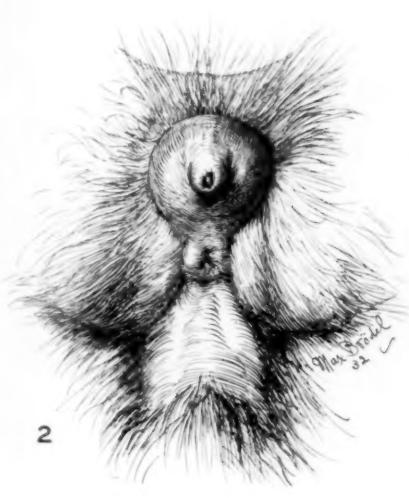
corresponds in structure to the adjacent skin. The inner or medial surface is as a rule free of hair but is nevertheless richly supplied with sebaceous glands and sweat glands. The labia majora are homologous to the scrotum in the male and at their upper ends receive the termination of the round ligaments. The labia majora and scrotum arise in the respective sexes from a fetal structure, the so-called labioscrotal fold.

The labia minora by definition are two thin folds of tissue lying medially to the labia majora, hairless, covered by stratified epithelium and containing numerous sebaceous and some sweat glands. They present a moist, reddish appearance, similar to that of a mucous membrane. Each labium minus divides anteriorly into two lamellae which fuse respectively with similar folds of the opposite side to form the frenulum clitoridis and the preputium. There is some disagreement, which need not be outlined here, as to whether the labia minora fuse imperceptibly with the labia majora to form the posterior commissure of the rima pudendi or whether they retain their identity as an independent low ridge bordering the posterior wall of the vulva.

When one considers the variable morphology of the folds surrounding the vulva in the various Primates, it becomes evident that strict adherence to the definition for labia majora as derived from the human becomes impossible. Obviously many of the charateristics which define the human labia majora are extremely modified or absent in other Primate forms. Klaatsch (1890, 1892), confronted by the difficulties of establishing the presence and location of labia majora in monkeys, resorted to a procedure based upon the homology of scrotum and labia majora. The wisdom of this course is apparent and it is the method which has been adopted here. Detailed embryological study of course should be equally important, but there is not enough material available at present to have recourse to that method.

Comparing the scrotum with the parts of the female, Klaatsch (1890) decided that catarrhine monkeys possess neither scrotum nor labia majora, but that platyrrhine monkeys (*Hapale, Cebus*) may have labia majora corresponding in a most striking way to the scrotum of the male. Bolk (1907), using the same method, found labia majora in *Alouatta, Ateles, Chrysothrix and Nyctipethecus* (*Aotus*); moreover, in catarrhine fetuses of undetermined genus he announced the discovery of the anlage of labia majora corresponding to similar scrotal rudiments which he observed in male specimens. He believed that these rudiments of scrotum and labia majora were destined to undergo complete or partial disappearance in postnatal life.





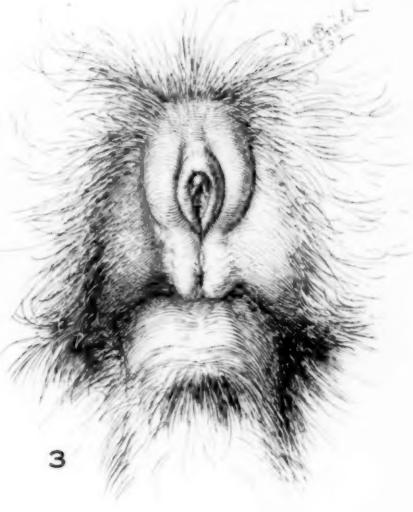
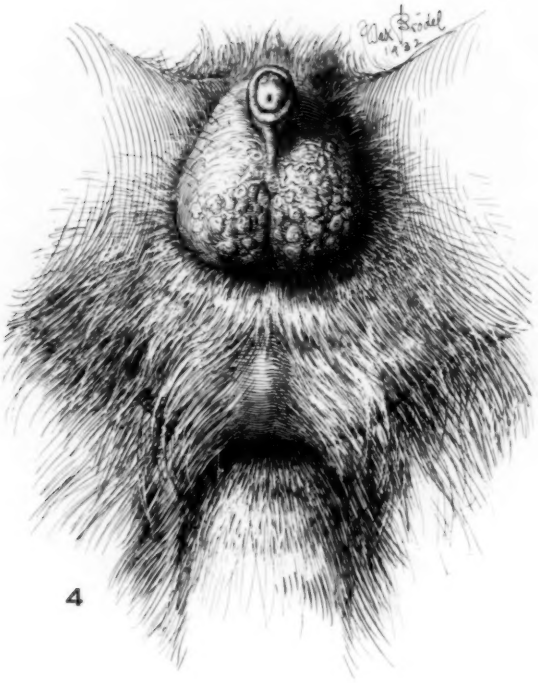


FIG. 1. MARMOSET. *Oedipomidas geoffroyi*. ADULT FEMALE.
FIG. 2. NIGHT MONKEY. *Aotus zonalis*. ADULT MALE.
FIG. 3. NIGHT MONKEY. *Aotus zonalis*. ADULT FEMALE.



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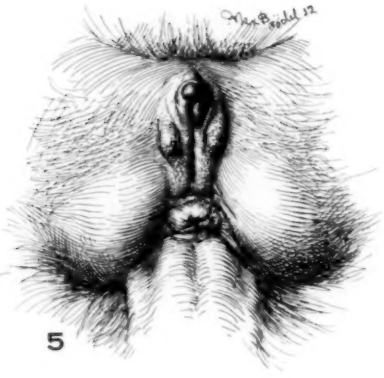

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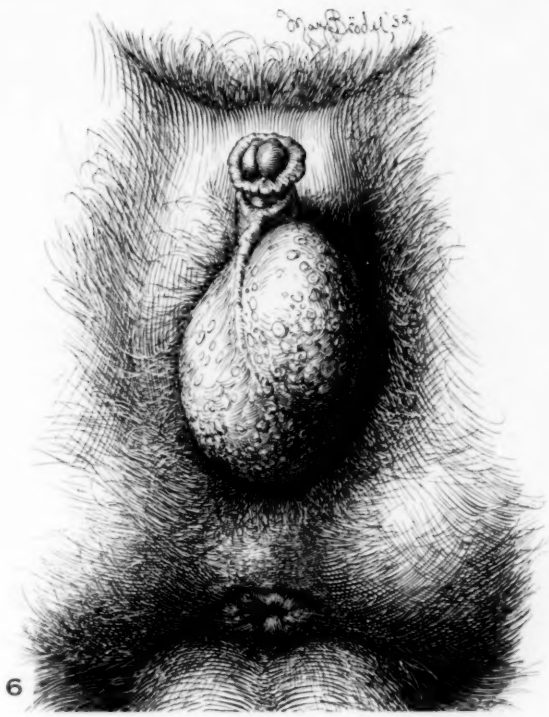
Fig. 4. Squirrel Monkey. *Saimiri örstedii.* Adult Male.

Fig. 5. Squirrel Monkey. *Saimiri örstedii.* Adult Female.



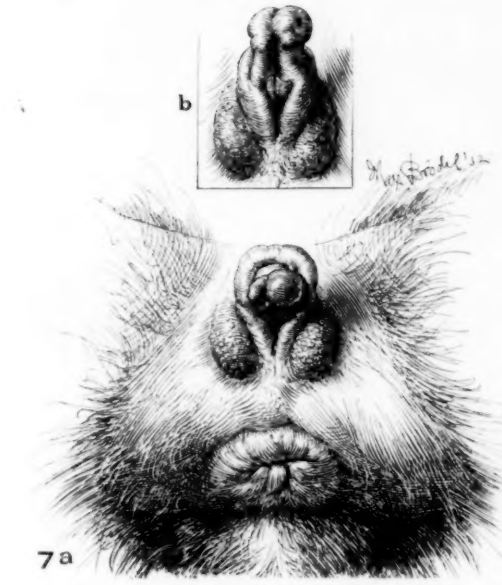
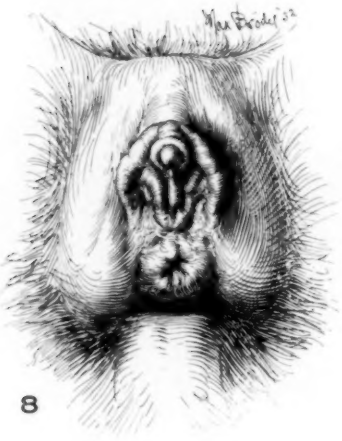


Fig. 6. Capuchin Monkey. *Cebus capucinus.* Adult Male. Penis and Prepuce Somewhat Distorted and Swollen.

Fig. 7a. Capuchin Monkey. *Cebus capucinus.* Adult Female. Clitoris Somewhat Distorted and Swollen.

Fig. 7b. The Same with the Clitoris Elevated.



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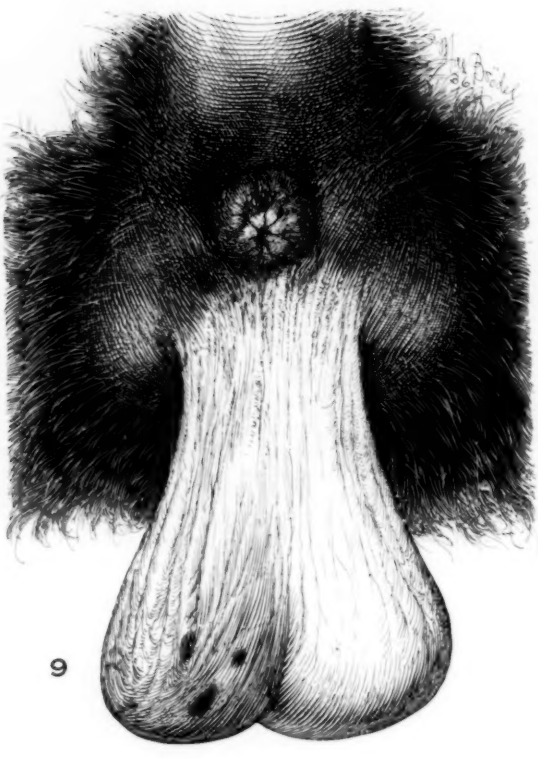

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FIG. 8. HOWLING MONKEY. *Alouatta palliata*. JUVENILE MALE.
FIG. 9. HOWLING MONKEY. *Alouatta palliata*. ADULT MALE.
Animal standing

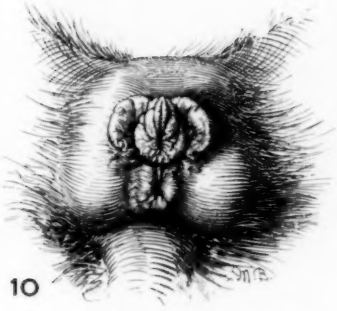
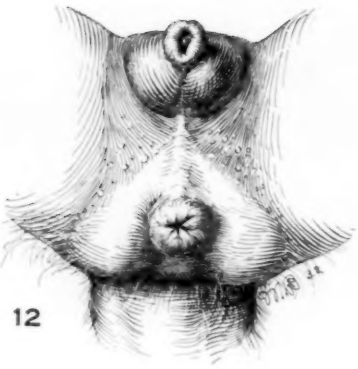
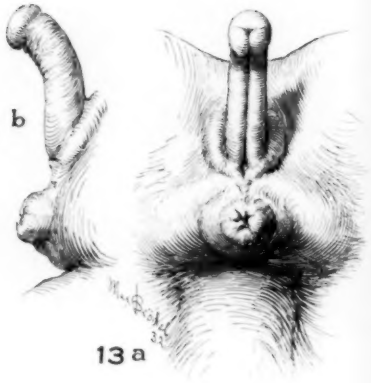


FIG. 10. HOWLING MONKEY. *Alouatta palliata.* NEWBORN FEMALE.
FIG. 11. HOWLING MONKEY. *Alouatta palliata.* ADULT FEMALE.
Animal standing





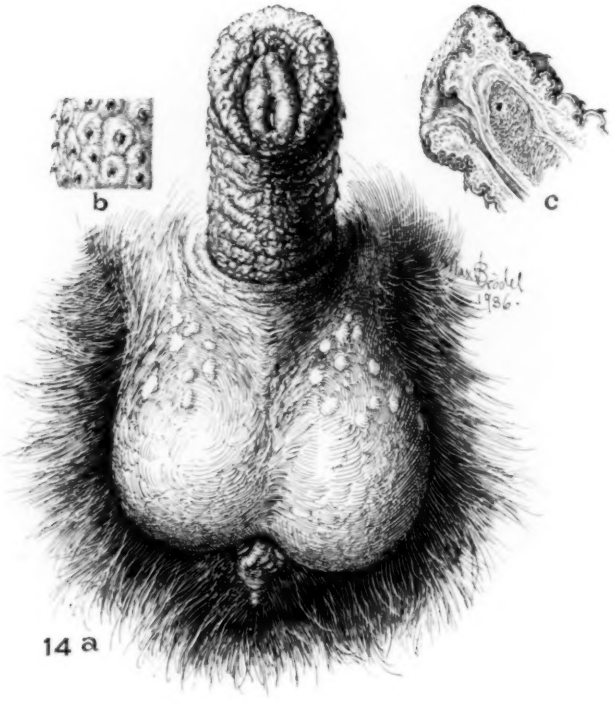


Fig. 12. Spider Monkey. *Ateles geoffroyi.* Male Fetus.

Fig. 13a. Spider Monkey. *Ateles geoffroyi.* Female Fetus.

Fig. 13b. Side View of the Same, Showing the Labial Fold at Base of Clitoris.

Fig. 14a. Spider Monkey. *Ateles geoffroyi.* Adult Male.

Fig. 14b. Surface of Penis, Magnified to Show Detailed Character of Cornified Denticles.

Fig. 14c. Sagittal Section Through Tip of Penis.

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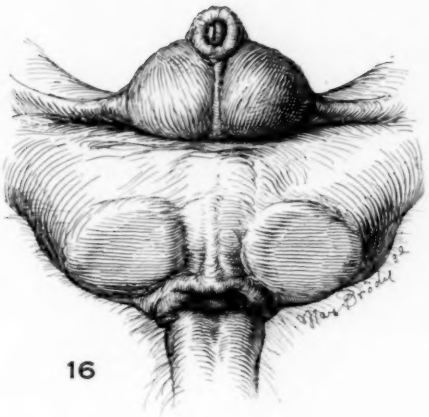

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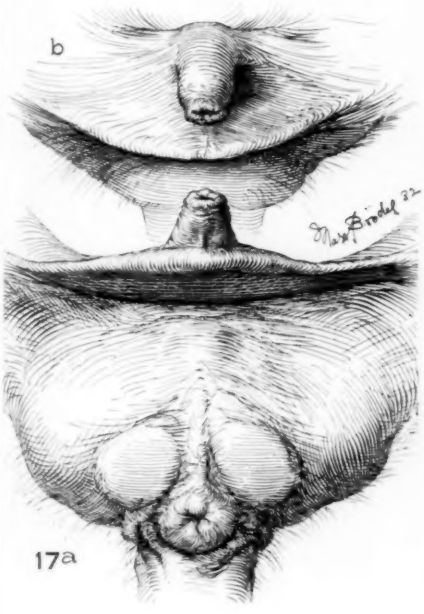

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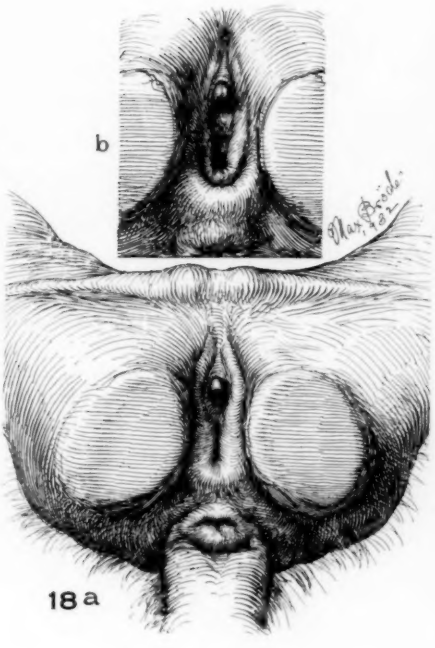

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Fig. 15. Rhesus Monkey. *Macaca mulatta.* Male Fetus.

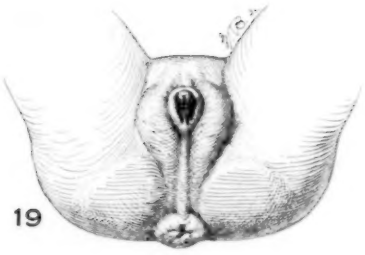
Fig. 16. Rhesus Monkey. *Macaca mulatta.* Male Fetus at Term.

Fig. 17a. Rhesus Monkey. *Macaca mulatta.* Infant Male, Viewed from Behind.

Fig. 17b. The Same in Ventral View.

Fig. 18a. Rhesus Monkey. *Macaca mulatta.* Newborn Female.

Fig. 18b. The Same with the Labia of the Rima Pudendi Slightly Spread.



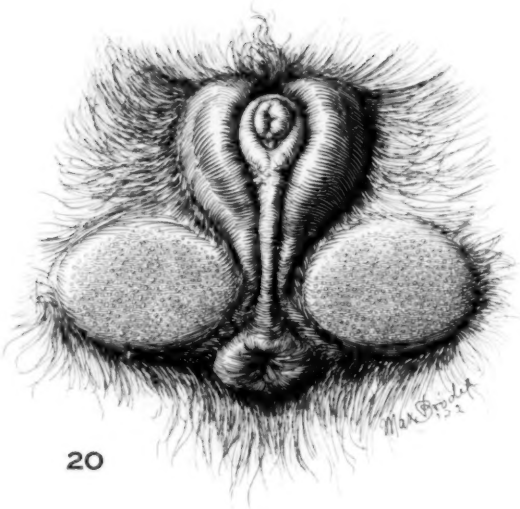
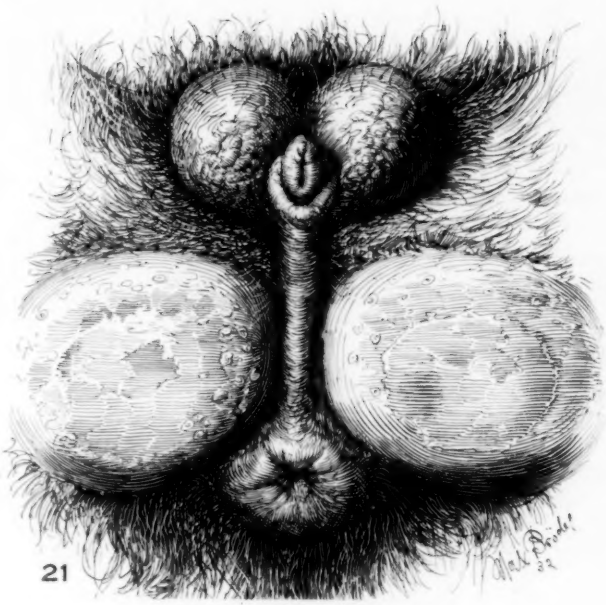


Fig. 19. Gibbon. *Hylobates pileatus*. Male Fetus.

Fig. 20. Gibbon. *Hylobates cinereus*. Juvenile Male.



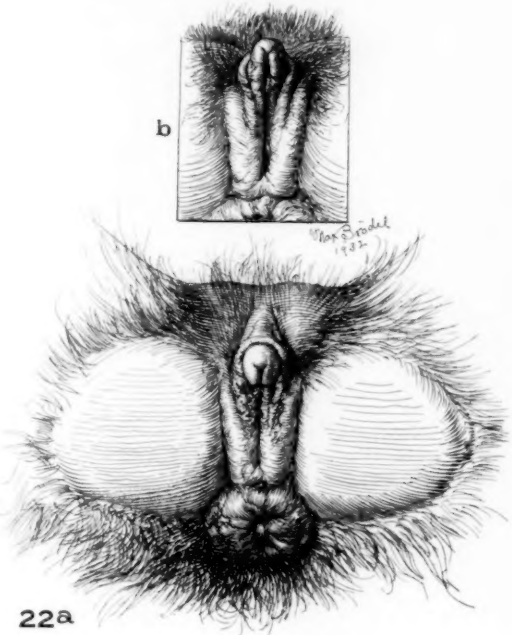


Fig. 21. Gibbon. *Hylobates cinereus.* Adult Male.

Fig. 22a. Gibbon. *Hylobates agilis.* Young Adult Female.

Fig. 22b. The Same with the Clitoris Elevated and the Labia Slightly Spread.

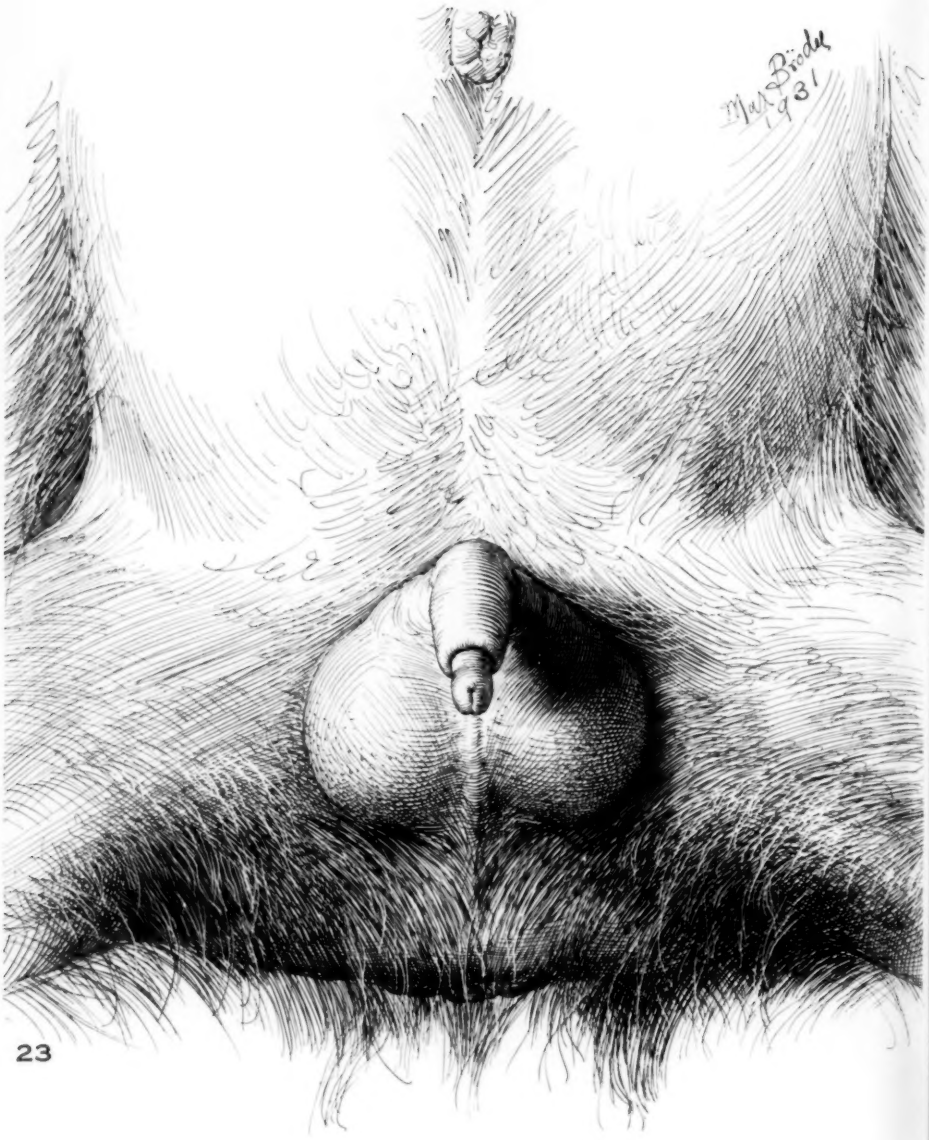
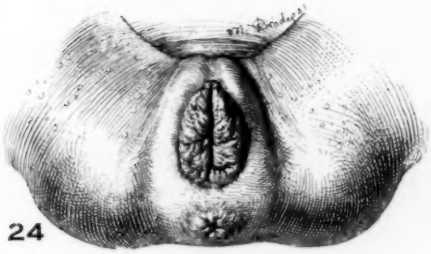


Fig. 23. Chimpanzee. *Pan.* Juvenile Male.

Fig. 24. Chimpanzee. *Pan.* Female Fetus.

Fig. 25a. Chimpanzee. *Pan.* Juvenile Female. Clitoris Somewhat Distorted and Swollen.

Fig. 25b. The Same with the Clitoris Elevated.



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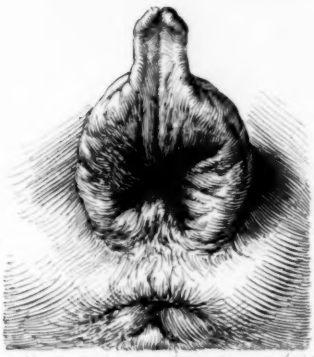

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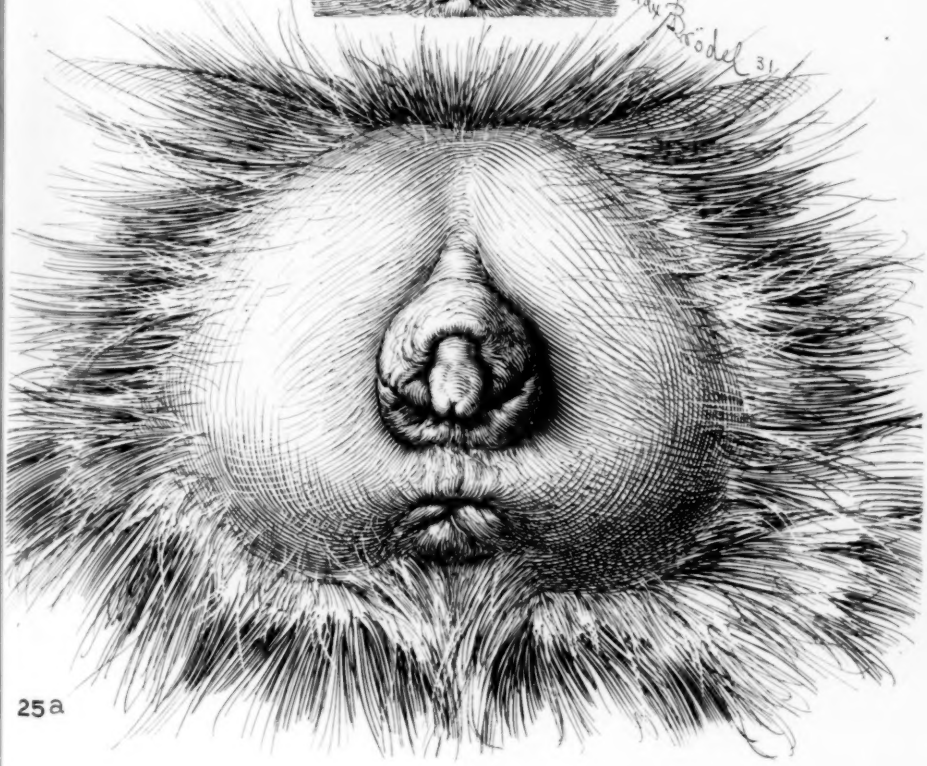

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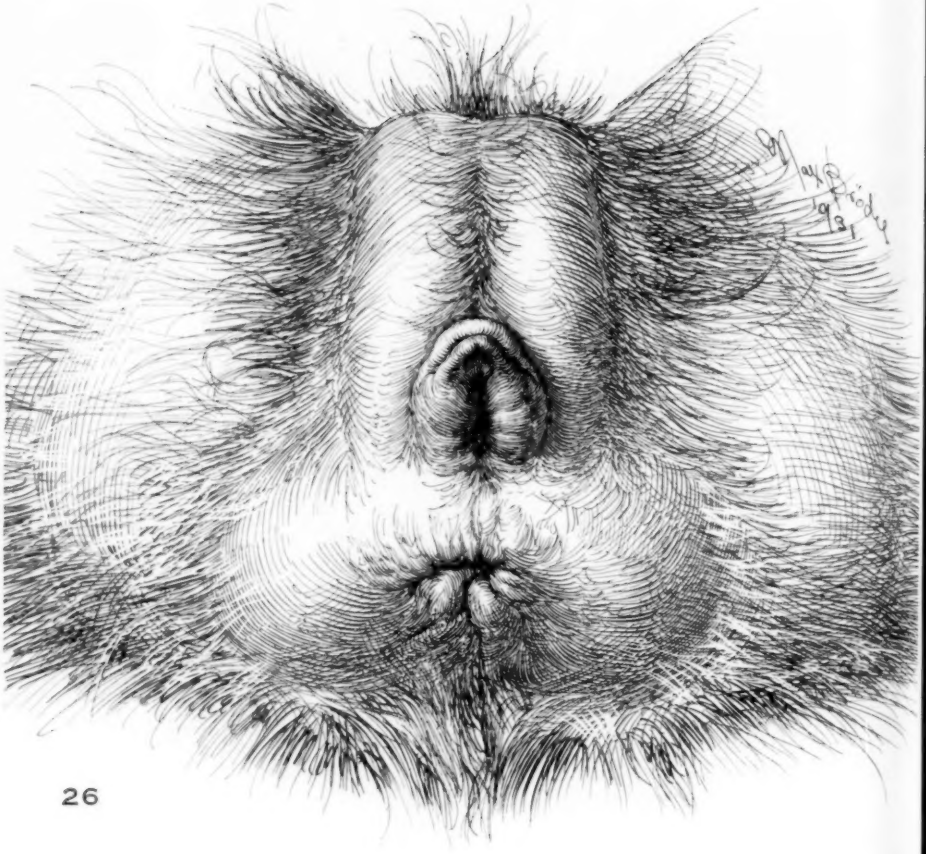

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Fig. 26. Chimpanzee. *Pan.* Juvenile Female.

Fig. 27. Orang Utan. *Pongo pygmaeus.* Female Fetus.

Fig. 28. Gorilla. *Gorilla gorilla.* Female Infant.

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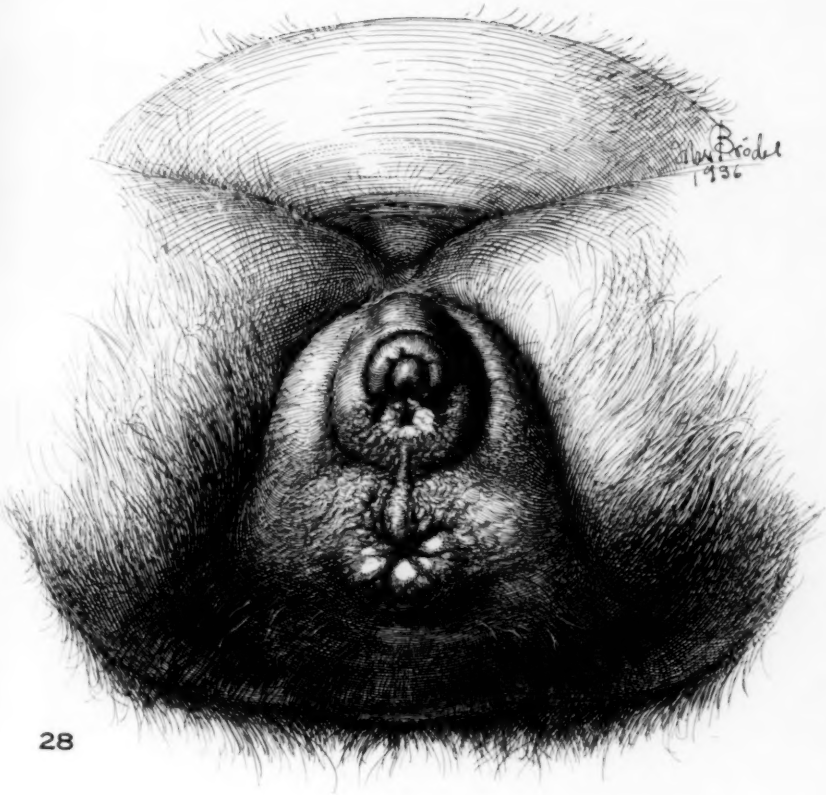

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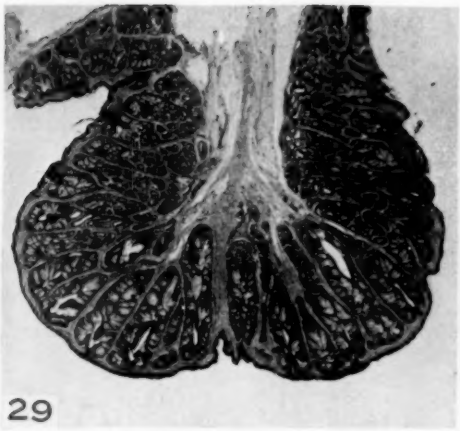

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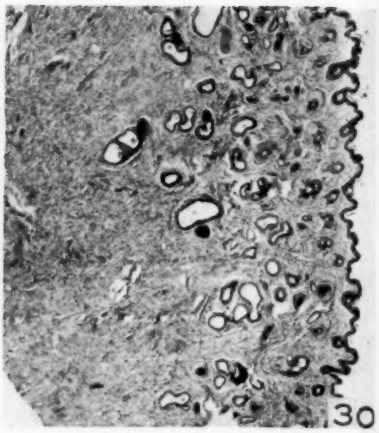

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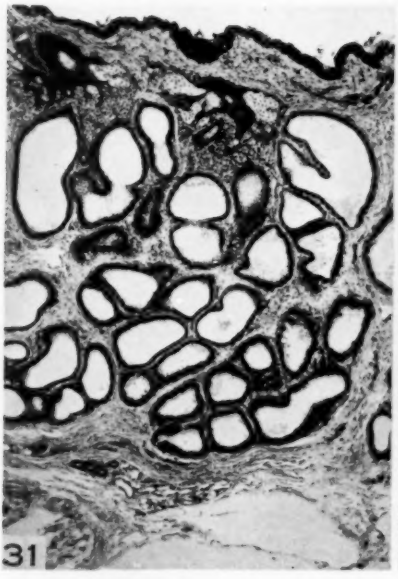

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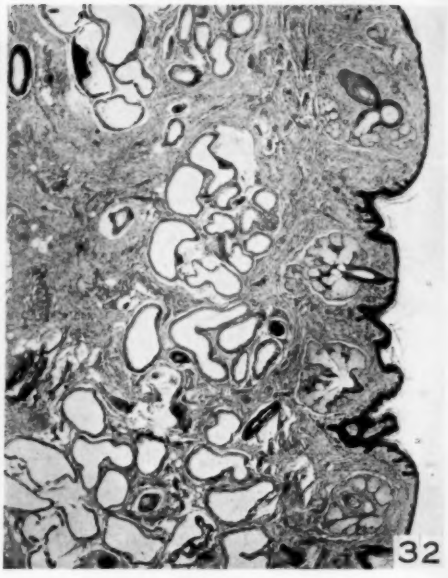

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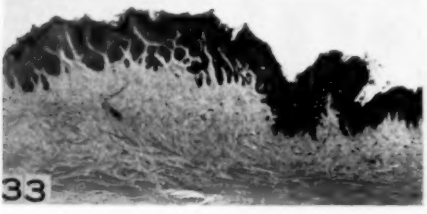

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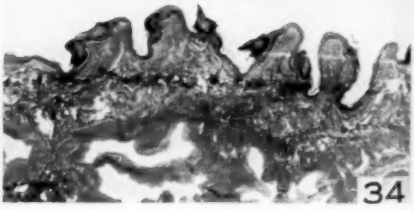

34

Fig. 29. Section Through the Glandular Organ (Labium Majus) of a Marmoset (*Oedipomidas geoffroyi*). × 6.

Fig. 30. Section Through the Glandular Pubic Skin of a Male Marmoset (*Oedipomidas geoffroyi*). × 40.

Fig. 31. Section Through a Glandular Labium Majus of a Squirrel Monkey (*Saimiri örstedii*). The gross specimen from which this section of the labia majora was obtained is shown in Fig. 5. The glandular labia majora are clearly visible in the gross specimen to either side of the vulva. × 20.

Fig. 32. Section Through a Glandular Labium Majus of a Capuchin Monkey (*Cebus capucinus*). In the gross specimen (Fig. 7) from which this section was obtained the glandular labia majora can be clearly seen to either side of the vulva. × 20.

Fig. 33. Vaginal Epithelium of Adult Spider Monkey (*Ateles geoffroyi*) Showing Cornified Outer Epithelial Layer and Minute Cornified Denticles. × 6.

Fig. 34. Section of the Surface of Penis of Spider Monkey (*Ateles geoffroyi*) Showing Horny Denticles. Compare this section with the macroscopic character of the denticles shown in Fig. 14b. × 6.

Our own observations are more extensive than those of either of the two previous workers and shed some new light upon the problem.

Platyrrhines. From comparison of our figures of platyrrhine monkeys which include specimens of *Oedipomidas, Aotus, Cebus, Saimiri, Alouatta,* and *Ateles,* there seems little doubt that scrotum and labia majora are fully represented and are strikingly analogous in position and configuration.

A few features deserve, however, to be especially pointed out. In *Oedipomidas geoffroyi* the scrotum is unusual in that in addition to the scrotal sac proper there are two ridges of similarly differentiated tissue which extend rostrally onto the abdomen. In the female the corresponding ridges are more conspicuous even than in the male (Fig. 1).

In *Alouatta palliata* we find an excessive development of both labia majora and minora leading in the adult to the formation of a semipendulous labial pad strikingly analogous in form, color and location to the pendulous scrotum of the male (Figs. 9 and 11).

In *Ateles geoffroyi* comparison of male and female genitalia leads us to the conclusion that the labia majora are feebly and variably represented by folds bordering the rima pudendi and the base of the large clitoris. Further comparison indicates that the much elongated clitoris is composed of an hypertrophied prepuce, beset with hairs, which conceals the actual hairless clitoris excepting for a depressed spot and furrow, continuous with the rima, on the ventral surface of the appendage. The labia minora are concealed from view within the vestibule.

Catarrhines. In the female rhesus monkey our observations confirm the opinion of Bolk (1907), reached from study of several male and female catarrhine fetuses of undetermined species, that a transverse fold exists rostral to the clitoris in the region of the pubis. Because of the striking homology with the scrotum in the male we accept this fold as representing the labia majora. Contrary to the belief of Bolk that in postnatal life all traces of this fold disappear permanently, the observations of Hartman (1928), as well as our own, indicate that the structure reappears in the rhesus monkey at the time of puberty. Hartman also points out the homology of the fold with the scrotum. Fragmentary observations on other catarrhine monkeys indicate that almost identical labial folds are present in other species.

These findings necessitate accepting that the labia majora have become dissociated from the vulva, taking up a position rostral to the clitoris corresponding to the location of the scrotum. Nevertheless there may be a further component of the labia majora contiguous to the pudendal cleft. The evidence for such an interpretation is presented in detail in the previous section on the female rhesus monkey. It is in accord, moreover, with the conditions observed in female gibbons, where there is considerable evidence indicating the presence of rostral as well as caudal components of the labia majora.

Gibbons. In the gibbons our observations indicate that the labia majora are represented in fetal life by relatively extensive structures extending from the pubic region caudalward, forming the borders of the pudendal cleft, and reaching almost to the anus. These structures coincide with the extent of the scrotum in the young male. In postnatal life the topography of the labia majora becomes very much obliterated. Nevertheless, study of a series of juvenile and adult gibbons indicates that the labia majora are recognizable, consisting of rostral components dissociated from the vulva, and of caudal components forming the borders, beset with hairs, of the anal half of the pudendal cleft. The labia minora, more medially situated, form the hairless borders of the anterior half of the rima pudendi in proximity to the clitoris.

It would be of interest to trace the labia majora in gibbons, as well as in the macaque, by embryological studies, material for which is unfortunately at present not at hand.

Great apes and man. The conclusion appears reasonably substantiated that in fetal and early postnatal life labia majora are present in all anthropoid apes and in man. With the exception of man, in which they persist, the labia majora undergo ontogenetic reduction. In the chimpanzee, nevertheless, the reduction may never be complete. In a position homologous to the scrotum, for the most part rostral to the rima pudendi, labial folds may be observed in postnatal life, varying in degree of development in individual chimpanzees.

In the orang and gorilla the labia majora are well defined in early life. In the former they appear to undergo a variable degree of reduction during postnatal life, while in the gorilla no examination of juvenile or adult females has been made.

From the literature and the present study the following generalizations regarding the labia majora of the Simiae have been reached.

1. Using homology with the scrotum as a standard, labia majora are found to be present in all groups of the Simiae.

2. In the platyrrhine monkeys they are well-developed structures flanking the pudendal cleft.

3. In the catarrhine monkeys they lie in the main rostral to the pudendal cleft in a homologous location to the scrotum.

4. In the gibbons they lie in part rostral to, in part flanking the pudendal cleft in close homology with the location and extent of the infantile scrotum. Never conspicuously developed in the gibbons, they undergo considerable ontogenetic reduction.

5. In the three great apes, well developed in fetal life, the labia majora undergo marked postnatal reduction. In addition to bordering the pudendal cleft, they extend rostrally occupying a field homologous to the scrotum. They lie lateral to and do not conceal the protruding labia minora and clitoris.

6. In man the labia are similar in late fetal life, in their topography and extent, to the fetal labia of the three apes. They do not, however, undergo reduction in postnatal life, but persist as conspicuous folds bordering the pudendal cleft and concealing the labia minora and clitoris.

7. The labia majora reflect the character of the scrotum, and in many species of platyrrhine monkeys immitate the morphology of the scrotum to a striking degree. In the catarrhine monkeys, gibbons and apes, in which the scrotum is located relatively far rostrally, widely separated from the anus, the labia majora become partially or in the main dissociated from the pudendal cleft and the clitoris which remain relatively close to the anus. The location of the labia majora depends apparently more upon a relationship to the scrotum than upon any obligatory association with the clitoris and rima pudendi. Indeed, in the male also, the scrotum may exhibit a certain degree of independence of the penis, as shown by the postpenial, parapenial and prepenial positions in which it is located in various species of gibbons.[3]

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[3]An interesting example in the human of the independence of scrotum and penis was brought to our notice recently. A male infant of five months, admitted to the Children's Hospital, Boston, had an apparently normal scrotum with descended testes in the usual position. The penis of about normal size and with slight hypospadias was completely dissociated from the scrotum, protruding ventral to the anus with a gap of about three centimeters between it and the caudal border of the scrotum.

The scrotum and labia majora as glandular organs in certain platyrrhine monkeys.

Attention is drawn here to an interesting phase of this study, namely, the occurrence of extensive glandular differentiation of scrotum and labia majora in the *Callitrichidae* (marmosets), *Cebus capucinus* and *Saimiri örstedii*. Previous observations with which we are acquainted regarding this subject are confined solely to the marmosets and are brief.

Thus Friedenthal (1910) says that the scrotum of the marmosets is richly supplied with glands which produce a musk-like secretion, the odor of which even clings to the trees on which the animals disport themselves during the mating season. Pocock (1920) remarks that in a female specimen of *Callithrix jacchus* there are numbers of whitish pustules around the anus, on the perineum and on the ischial prominences which exude under pressure a sebaceous substance which may be odoriferous. In a male of the same species he states that the similar region including the scrotum is studded with whitish glandular pustules. Beattie (1927) says of *Hapale jacchus* that the scrotum is covered with pearly white nodules, and that the skin of the perineum in the female is studded with numerous nodules resembling the condition seen in the male. Moreover, in the female these nodules are found anteriorly as far as the upper level of the body of the pubis and posteriorly as far as the root of the tail. Weber (1928) mentions merely the presence of scent glands in the *Hapalidae*, while Wood Jones (1929) remarks that no definite scent glands have been described in the marmosets. Wislocki (1930) gives a full description with illustrations of the gross and microscopic appearance of the external genitalia of *Oedipomidas geoffroyi* in which it is shown that in adults there is extensive glandular tissue reaching from anus to pubis including scrotum or labia majora. He points out that these glands are much more extensively developed in the female than in the male, and that microscopic examination reveals them to be complexly modified, tubular and sebaceous glands. In the female the glandular masses form a raised circumgenital pad with two cushion-like extensions extending over the symphysis. Examination shows further that similar glandular complexes are present in *Callithrix penicillata* and *Callithrix jacchus*. In 1935 Russell and Zuckerman reported a similar condition in a female *Hapale albicollis* (?). An area referred to by them interchangeably as the circumgenital pad, "sexual skin," labia majora or perineal swelling is said to be pedunculated, turgid and to be composed histologically of a moderate number of glands imbedded in oedematous stroma. The condition described by them differs mainly from that demonstrated by Wislocki in *Oedipomidas* by virtue of the oedema and the lesser development of glandular tissue. The histological appearance of the swelling in *H. albicollis* is said to resemble the "sexual skin" of catarrhine monkeys. Moreover it was stated by those who had charge of the animal during life that the genital swelling underwent cyclical changes. Our own material from *Oedipomidas* sheds no light upon the question of cyclical manifestations.

In addition to the marmosets we can now state definitely that similar glandular differentiation occurs in two other genera of platyrrhine monkeys. On examining healthy adult specimens of *Cebus capucinus* and *Saimiri örstedii,* our attention was attracted to whitish nodules upon the scrotum. Upon turning to adult females the homologous labia majora were found to be in a miniature way almost replicas of the scrotum. The labia majora formed small mounds or hillocks of tissue to either side of the vulva. The surface of these hillocks was nodular and pitted even more pronouncedly than the scrotum, the appearance suggesting the presence of glandular tissue. This surmise was fully verified by making histological preparations of labia majora as well as of scrotum. As in the marmosets the glands were larger, more numerous and more active in the female than in the male. Figures 31 and 32 present photographs of sections of the labia majora of *Saimiri örstedii* and *Cebus capucinus.* The glands are of both tubular and sebaceous varieties and are sufficiently extensive and active to warrant considering them as specialized glandular organs involving the labia majora. In conclusion it may be stated that the presence of specialized scent glands, involving the circumgenital region, is characteristic of *Oedipomidas geoffroyi, Cebus capucinus* and *Saimiri örstedii.* Although present in both males and females, in the latter the glands achieve their greatest development.

LITERATURE CITED

Beattie, J. 1927. The anatomy of the common marmoset (*Hapale jacchus Kuhl*). *Proc. Zool Soc. London,* pp. 593-718.

Bischoff, T. L. W. von. 1879. Vergleichende anatomische Untersuchungen über die äusseren weiblichen Geschlechts- und Begattungsorgane des Menschen und der Affen, insbesondere der Anthropoiden. *Abhandl. math. phys. Cl. K. Bay. Akad. d. Wiss. München.,* vol. 13, pt. 2, pp. 207-273.

———. 1880. Ueber die äusseren weiblichen Geschlechtsteile des Menschen und der Affen. Nachtrag. *Abhandl. math. phys. Cl. K. Bay. Akad. d. Wiss., München,* vol. 13, pt. 3, pp. 169-297.

Bolk, L. 1907. Beiträge zur Affen-anatomie. VI. Zur Entwickelung und vergleichende Anatomie des Tractus Urethro vaginalis der Primaten. *Zeitschr. f. Morph. u. Anthropol.,* vol. 10, pp. 250-316.

De Beaux, O. 1917. Osservazioni morfologiche e sistematiche sul penis del "Macacus arctoides", Js. Geoffr. e di cinque altre specia di Macachi. *Gior. Morf. del Uomo e del Primati,* vol. 1, pp. 1-12.

Deniker, J. 1885. Recherches anatomiques et embryologiques sur les singes anthropoides. *Arch. zool. exper.* ser 2, vol. 3, *Suppl. Mém.* III, pp. 1-265.

DUCKWORTH, W. L. H. 1898. Note on a foetus of *Gorilla savagei*. *Jour. Anat. and Physiol.*, vol. 33, pp. 82-90.

DUVERNOY, G. L. 1855-56. Des caractères anatomiques des grands singes pseudo-anthropomorphes. Vol. 8, 3rd Mém., Chap. 3. Des organes males de génération du gorille, pp. 208-210.

EHLERS, E. 1881. Beiträge zur Kenntnis des Gorilla und Chimpanse. *Abh. d. K. Gesell. d. Wissensch. zu Göttingen, Phys. Cl.* 28, pp. 3-77.

FICK, RUDOLF. 1895. Vergleichend anatomische Studien an einem erwachsenen Orang-Utan. *Arch. f. Anat. u. Entwick.*, pp. 1-96.

FISHER, E. 1898. Beiträge zur Anatomie der weiblichen Urogenitalorgane des Orang-Utan. Inaug. Diss. Freiburg i. Br. G. Fischer, *Jena*, pp. 1-66.

FRIEDENTHAL, H. 1910. Sonderformen der menschlichen Leibesbildung. *Beitraege zur Naturgeschichte des Menschen.* Vol. 5, Jena, pp. 1-100.

FUGGER, A. G. F. 1835. De singulari clitoridis in simiis generis Ateles magnitudine et conformatione. Dissertation. *Berlin.* pp. 1-24. 3 plates.

GERHARDT, U. 1906. Die Morphologie des Urogenitalsystems eines weiblichen Gorilla. *Jenaische Zeitschr. f. Naturwiss.*, vol. 41, pp. 632-654.

———. 1909. Ueber das Vorkommen eines Penis-und Clitoris-knochens bei Hylobatiden. *Anat. Anz.* vol. 35, p. 353-358.

HARTMAN, C. G. 1928. The period of gestation in the monkey, *Macacus rhesus*, first description of parturition in monkeys, size and behavior of the young. *Jour. Mammalogy*, vol. 9, pp. 181-194.

HARTMAN, ROBERT 1886. Anthropoid Apes. Internat. Scien. Ser. D. Appleton & Co. *New York.*

HOFFMANN, G. VON. 1878. Über die weiblichen Genitalien eines Schimpanze. *Zeitschr. f. Geburtshilfe u. Gyn.*, vol. 2, p. 1.

KLAATSCH, H. 1890. Ueber den Descensus testiculorum. *Morph. Jahrb.*, vol. 16, pp. 587-646.

———. 1892. Ueber embryonale Anlagen des Scrotums und der Labia majora bei Arctopitheken. *Morph. Jahrb.*, vol. 18, p. 383.

KOFF, A. K. 1933. The embryology of the female generative tract. Obstetrics and Gynecology. Ed. by A. H. Curtis. Saunders. *Phil. and London*, vol. 1, pp. 557-595.

KOHLBRUGGE, J. H. F. 1892. Versuch einer Anatomie des Genus Hylobates. Zool. Ergeb. einer Reise in Nied. Ostindien. Herausgegeben von Max Weber. Bd. 2. *Leiden.* Pt. 2. Urogenitalsystem, pp. 185-186.

MILLER, G. S. JR. 1933. The classification of the gibbons. *J. Mammalogy*, vol. 14, pp. 158-159.

MIJSBERG, W. A. 1923. Ueber den Bau des Urogenitalapparates bei den männlichen Primaten. *Verh. Konin. Akad. v. Wetenschappen. Amsterdam*, Ser. 2, Pt. 13, No. 1, pp. 1-92.

POCOCK, R. I. 1920. On the external characters of South American monkeys. *Proc. London Zool. Soc.*, pp. 91-113.

———. 1925a. Additional notes on the external characters of some platyrrhine monkeys. *Proc. London Zool. Soc.*, pp. 27-47.

———. 1925b. The external characters of the catarrhine monkeys and apes. *Proc. London Zool. Soc.*, pp. 1479-1577.

———. 1927. The gibbons of the genus *Hylobates*. *Proc. Zool. Soc. London*, pp. 719-741.

POHL, LOTHAR. 1928. Zur Morphologie der männlichen Kopulations-organe der Säugetiere; insbesondere der Versuch einer vergleichend-anatomischen Studie über den Penis der Primaten, einschliesslich des Menschen. *Zeitschr. f. Anat. u. Entw.*, vol. 86. pp. 71-119.

POUSARGUES, E. DE. 1895. Note sur l'appareil genital male des orang-outans. *Nouv. Arch. du Mus. d'His. Nat. Paris.* Ser. 3, vol. 7, pp. 56-82.

RUSSELL, A. E. and S. ZUCKERMAN. 1935. A "sexual skin" in a marmoset. *J. Anat.*, vol. 69, pp. 356-363.

SCHULTZ, A. H. 1927. Studies on the growth of *Gorilla* and of other higher Primates with special reference to a fetus of *Gorilla*, preserved in the Carnegie Museum. *Mem. Carnegie Museum*, vol. 11, no. 1, pp. 1-86.

SELENKA, E. 1903. Studien über Entwickelungsgeschichte. Heft 10, Menschenaffen. Entwickelung des Gibbon (*Hylobates und Siamanga*) pp. 163-201.

SONNTAG, C. F. 1924. The Morphology and Evolution of the Apes and Man. *London.* Bale.

SPAULDING, M. H. 1921. The development of the external genitalia in the human embryo. *Carnegie Contrib. to Embryology*, vol. 13, pp. 67-88.

SPERINO, G. 1897. Anatomia del Chimpanzè. *Torino.*

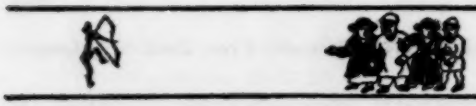
SYMINGTON, J. 1890. On the viscera of a female chimpanzee. *Proc. Roy. Phys. Soc.*, vol. 10, pp. 297-312.

WEBER, *Max*. 1928. Die Säugetiere. 2d ed. *Jena.* Fischer.

WISLOCKI, G. B. 1930. A study of scent glands in the marmosets, especially *Oedipomidas geoffroyi*. *J. Mammalogy*, vol. 11, pp. 475-483.

———. 1933. Observations on the descent of the testes in the macaque and in the chimpanzee. *Anat. Rec.*, vol. 57, pp. 133-148.

WOOD JONES, F. 1929. Man's place among the mammals. *New York.* Longmans, Green & Co.



THE ZONES AND STRATA THEORY— A BIOLOGICAL CLASSIFICATION OF RACES

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I. INTRODUCTION

IN 1919 the writer published a classification of human races which departed in a number of respects from current classifications. His chief interest in science for the past fifteen years has been in the early history of the human races, especially in their differentiation and migration, and he is now even more sure in his belief that the somewhat new tools and methods then employed, if adopted more generally, would in considerable measure modify current classifications.

Two quotations from authoritative books will emphasise his point of view. Kroeber (in his standard *Anthropology*) writes: "The only classification that can claim to rest upon a true or natural basis is one which takes into consideration *as many traits as possible*.....and weights the more important more heavily than the unimportant features." The present writer would like to see included under the word "traits" such factors as ecological distribution and archeological strata. Another pertinent quotation is from E. B. Tylor (in the article on Anthropology in the *Encyclopedia Britannica*), as follows: "The classification by Cuvier [about 1820] into Caucasian, Mongol and Negro corresponds in some measure with a division by mere complexion into white, yellow and black races.... but cannot be regarded as separating the human types either justly or sufficiently."

Strangely enough, the classification of Cuvier, made before Anthropology was a science, still seems to be the basis of most modern classifications. It is surely unusual for pre-scientific classifications to remain orthodox for so long a period, and the present writer has been completely unorthodox in this respect ever since he commenced his research in anthropology. It is the purpose of this paper to draw attention to an ecologist's approach to the problem, to the confirmation to be derived from modern biological research, and to suggest a classification of the races which seems to him more in harmony with the history of the races concerned.

Few anthropologists have given much attention to the fact that the environment during the critical period of man's differentiation was very different from that obtaining today. His routes of migration are by no means to be understood by mere reference to present-day topography and climate. The forces that set him migrating are not in general in action today. In other words, among the factors to be considered in evaluating our problem the changing environment is by no means to be neglected—and can give us many clues if used in connection with isopleths of present-day distribution.

II. THE GENERAL THEORY

It was his use on world maps of the isopleth method in charting the criteria of race, in conjunction with the findings in W. D. Matthew's memoir, "Evolution and Climate" (1915) (see bibliography at end), which led the writer to publish the Zones and Strata Classification of Races in 1919. The general principles of this concept are illustrated in Fig. 1. Here three parallel cases of evolution are considered.[1] All anthropologists will agree as to the explanation of the block diagram on the left. Here we see zones of *Methods of Transport* arranged round the city of Sydney—the only settlement

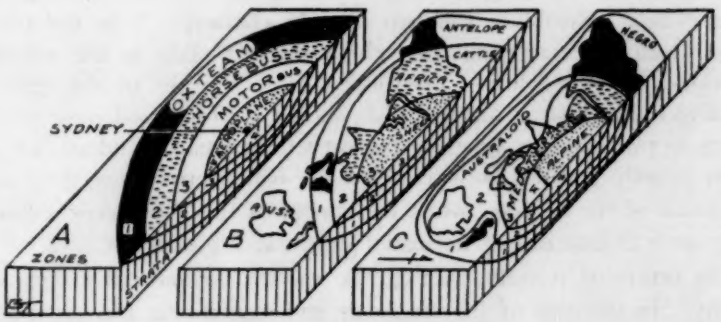

FIG. 1. THE ZONES AND STRATA CONCEPT APPLIED TO (A) EVOLUTION OF TRANSPORT, i.e., CULTURE, (B) EVOLUTION OF EVEN-TOED MAMMALS (BASED ON DATA BY MATTHEW) (C) EVOLUTION OF THE RACES OF MAN. In each case the "Cradleland" is at the centre of the Zones, and the earliest most primitive type (1) is pushed to the margin.

[1] A less complete account of this concept—which omitted the biological parallel—will be found in HUMAN BIOLOGY for February, 1930. The present paper is a supplement to the former.

of note for 60 years in Australia. The "strata," resulting from this evolution in Sydney and gradual migration to margin, are indicated on the vertical edge of the block diagram. Clearly there is a common cradleland, where commercial activity is greatest, in the centre of the zones—and the primitive types now occur precisely where they did *not* originate.

Turning to Fig. 1B, we find the same process illustrated in the evolution of the Artio-dactyls (or even-toed mammals) based on data given by Matthew. The antelopes are earliest and are displaced farthest from the centre. The sheep are latest and still characterise the common cradleland. The fossil strata are in accord, using the paleontologist's "Law of Superposition." No biologist doubts that the zones and strata in the case of these mammals indicate the order of migration and of *evolution* for the artio-dactyls.

The writer believes that primitive man was differentiated into the five major races long before the later races reached Western Europe. This evolution almost certainly took place in Asia and occurred before the last Ice Age. It certainly far antedated early Neolithic times.[2] Hence early man of such a primitive type can surely be considered as obeying the same laws of migration as the higher mammals. If now the pre-Columbian distribution of the races be plotted in a block diagram (Fig. 1C), we find a *series of zones and strata* closely resembling the two already charted. It is diffcult to escape from the conclusion that the centre of Asia is the common cradleland where evolution progressed most actively in the case of primitive man—just as Matthew has shown it progressed most actively here to produce new types of the earlier mammals. Indeed, we can almost exactly parallel the spread of the Rhinoceros from Asia with the spread of the negroes, while the spread of the Pleistocene Equidae is the same as that of Alpine man (Matthew, Figs. 20 and 17).

The centre of stimulus in Fig. 1A was the commercial progress in the city. In the case of the mammals and man it was the stimulating climate of south central Asia. I have in a number of books and papers (see bibliography) shown that this region in the past has been characterised to a marked degree by such climatic features, but lack of space prevents my covering this ground again.

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[2]It is probable that the first Alpine peoples reached France (Solutré, etc.) in Aurignacian times (*vide* A. Keith); and Koeppen dates this as far back as 74,000 years ago. Neolithic times in France were only 8,000 years ago.

TABLE 1

The Five Major Races

RACE	CRITERIA		HABITAT
	Head Index	Hair	
(Latest Migrations)			
Alpine-Mongolian (ruled in Fig. 3E)	88-83	Straight or wavy	Central zone and highest stratum. Extends from Swiss Alps to Manchuria (still in or near corridors of migration in Eurasia and America)
(Earlier)			
Alpine-Mongolian (Variants, Pareoean and Polynesian)	83-80	do	Second zone and second stratum in cradleland. Covers most of Asia and Central Europe. (Widespread in America.)
Mediterranean (Fig. 3D) (Variants, Nordic, Nesiot)	80-77	Wavy to curly	Submarginal zone. North Africa, South Asia, fringe in North Eurasia (sporadic in the east of America).
Australoid (Fig. 3C) (Varients, Pre-Dravidians, Veddah)	76-73	Wavy to curly	Marginal zone in 'peninsulas' of India and Australia. (Few reached America and Europe.)
Negro (Fig. 3B)	74-70	Frizzy	Marginal zone in southern Africa and in Melanesian Islands.
Negrito (Fig. 3A) (Earliest migrations)	About 80 Aberrant	do	Most marginal zone and lowest stratum. Inaccessible forests or deserts or small islands of Africa and Southeast Asia, etc.

The actual mechanism whereby the changing environment (especially the vegetation belts) led to the migrations of primitive man has been illustrated by the writer in his recent paper, "The Ecological Basis of Anthropology." Here in a series of four block-diagrams he shows how the changes of climate (from B. C. 18,500 onward) in Scandinavia produced the shift of belts of trees at the rate of perhaps three miles a century. Neolithic Man, Bronze Age Man, and Iron Age Man show (by their artefacts) that they migrated here in accord with climatic change.

The five major races (see Fig. 3), as deduced from their zonal distribution—and from their anthropological 'strata' in so far as we can reconstruct them, are given in Table 1.

III. THE HEAD INDEX

It will be noticed that in the above table the writer relies on head index and hair texture primarily. Charts by Biasutti will be found to demonstrate the reality of the racial zones (Fig. 1C) which were, however, deduced by the writer several years before he knew of Biasutti's maps (1912). Unfortunately, there is a distinct tendency today to depreciate the value of the head index as a racial criterion. This is in large part due to the research of Boas (1911) on the changes which the children of European immigrants experience if they are born in the city of New York. Everyone has heard that the head-breadth of the brakeph[3] Jew children decreases, and that the head-breadth of the dokeph[3] Neapolitan children increases with the change of birth place. But it is not so clearly realized how slight is the change—what factors have produced the change—and finally that Boas himself issues a cautionary statement with his findings.

> The average decrease in head-width in Hebrews merely amounts to 1.52 millimetres; which is just one per cent of the absolute width. (This would hardly affect the cephalic index by one unit.) In the case of the Neapolitans the increase is 0.48 millimetres—and the change (in some 140 mm.) is still slighter. Moreover, Boas very properly points out that certain measurements of the parent immigrants (such as width of head and width of face) varied steadily from 1880 to 1910— which variation certainly affects the importance of the change in their progeny born in New York. Moreover, the writer would like to be sure that the age-factor does not enter into the problem. There is usually a slight change in the head index as a child grows up—quite independent of his race. Venn (1889) showed this years ago for undergraduates at Cambridge (England). Here there

[3]Convenient contractions for brachycephalic and dolichocephalic.

was an increase from 77.9 to 79.2 during the period from 19 to 23 years old. On the other hand, A. Macalister (1897) states that there is in general a change toward brachycephaly as the child grows up. Since Boas is mainly dealing with young subjects (from birth to 25), this is a vital point.

A second point is that a mere change of life from country to city (e.g. in Italy) has considerable effect on physical measurements, as Livi has proved. To this also Boas refers, and allows that it may have a bearing on his investigation. His conclusion is very important. "The proof of plasticity of types does not imply that the plasticity is unlimited. The history of British types in North America, of the Dutch in the East Indies and of the Spanish in South America favors the assumption of a *strictly limited plasticity*."

In 1913 Boas discussed the conditions which arise in central Italy where the Alpine and Mediterranean races have been in contact for several thousand years. He plots the mean square variability of the cephalic index and shows that there has been not enough merging even here to invalidate the use of the cephalic index as a race-measurer.

The present writer feels that the slight non-continuous variations noted by Boas do not affect the validity of the cephalic index. How else can we account for the relative uniformity of the Alpine race (inhabiting high plateaux, hot plains, salty steppes, deserts, wet mountains, marshes and fertile lowlands) which extends from the Himalayas to the Bay of Biscay?

As Ripley (1900) writes, "The Galchas, Tadjiks and their fellows (of the Pamirs) are grey-eyed, dark-haired, stocky in build, with cephalic indices ranging above 86 for the most part. From this region a long chain of peoples of similar type extends uninterruptedly westward over Asia Minor and into Europe."

IV. CORRIDORS INTO THE CONTINENTS

It is of considerable interest to use our knowledge of the relative accessibility of the various continents, and to see how it agrees with the Zones and Strata Hypothesis.

Most anthropologists accept Asia as the cradleland of the Alpine, Mediterranean and Australoid Races. If we are to assume that the negroes or negritoes evolved in Africa, then we are faced with several cumbrous inconsistencies. Where did the negroes (and negritoes) of Melanesia and thereabouts come from? If Africa is suggested, the obvious reply is that it is far simpler to assume that both African and Melanesian negroes came from south Asia, i. e. the same centre of Racial Evolution as did the other races. Moreover, the Zones and Strata hypothesis leads us to believe (even if this be not actually proven) that primitive races persist in the marginal lands, precisely

where they did *not* evolve. The same arguments apply to the negritoes, and lead us to accept an Asiatic cradleland.

What was the relation of Africa, Australasia, and America to the Eurasian land-mass during the later Ice Ages—when we may surely picture these earlier racial migrations as occurring? Surely something like this. The easiest of access was Africa, for only the Red Sea—probably much less of a barrier then—separated that region of deserts and savannas from the cradleland (Fig. 2).

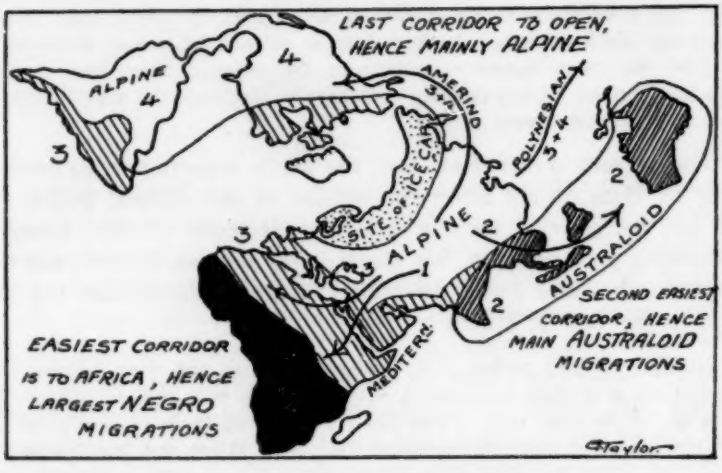

FIG. 2. THE ORDER OF THE MAJOR MIGRATIONS FROM ASIA AGREES WITH THE EASE OF COMMUNICATION WITH THE OUTLYING CONTINENTS BY MEANS OF THE MAIN CORRIDORS. Thus Africa, Australia and America could be entered in this order. The racial zones support this theory.

Australasia was the next most accessible. During the Ice Ages no doubt the broad low area of Sunda Land with the almost dry Bali-Timor ridge led to the large low Sahul Land and so to Australia. (See the writer's book, 1927.) In the Interglacial period both Sunda Land and Sahul Land were drowned as the result of the filling of the oceans by the melting Ice Caps. Hence we may postulate that Australia and Melanesia were on the whole much harder to reach than was Africa in those early days.

As regards America, all migrations must pass via northeast Siberia. In the Ice Ages this was covered with an Ice Cap (Taylor, 1930) which would definitely discourage migrations. During interglacials

the Behring route might be quite feasible—and doubtless during such a period a few tribes of Australoids or kindred folk reached America (Taylor, 1919). Possibly during the close of the Wurm Ice Age the Eskimo reached America while their congeners, late Paleolithic Man, were reaching Western Europe. The main migrations into America seem to have occurred in the warmer periods (say of the Achen retreat of the ice or between the Buhl and Schnitz minor advances of the ice in Europe) some ten to twenty thousand years ago.

Now assuming these geographical relations, what should we expect to find? Primitive man was thrust out of south central Asia (primarily by climatic changes leading to greater cold or aridity) and would know nothing of the outlying areas. He would no doubt move off in several directions (to south, southwest or southeast) more or less equally. Thus the greater proportion of the earliest migrations would inevitably reach Africa (the easiest outlet, on the whole), while a smaller number would reach Melanesia by circumventing the very difficult tangle of mountains in Southeast Asia, crossing the "stepping stones" of the East Indies; and, if fortunate enough, making use of the alternately open and drowned corridors of Sunda and Sahul Lands. This 'paired' dispersion to west and east is illustrated in Fig. 6.

As millenia passed the more accessible lands of Africa would fill up, and Australia would receive a much larger proportion of later (Australoid) migrations. Finally as the latest migrants were thrust from Asia, the American corridor became available—and this is why we find so large a proportion of the Alpine-Mongolian Race in the New World. A glance at the arrangement of the Zones (Fig. 3) will show that this series of migrations is fully corroborated.

V. THE NEGRITO ZONE

No feature of the classification adopted is entirely new, for the obvious reason that among the dozen latest classifications almost all reasonable methods have been suggested. But it is because the writer has applied a somewhat novel test—the ecological one—and finds that it lends support to one set of racial classes and not to the others that he adopts the former.

Let us consider the five classes in order of development (Fig. 3). Most anthropologists group the negritoes as a stunted variety of the negro, though Dixon has made them a variety of the Alpine. The writer's belief that they are relics of a very ancient type of man, con-

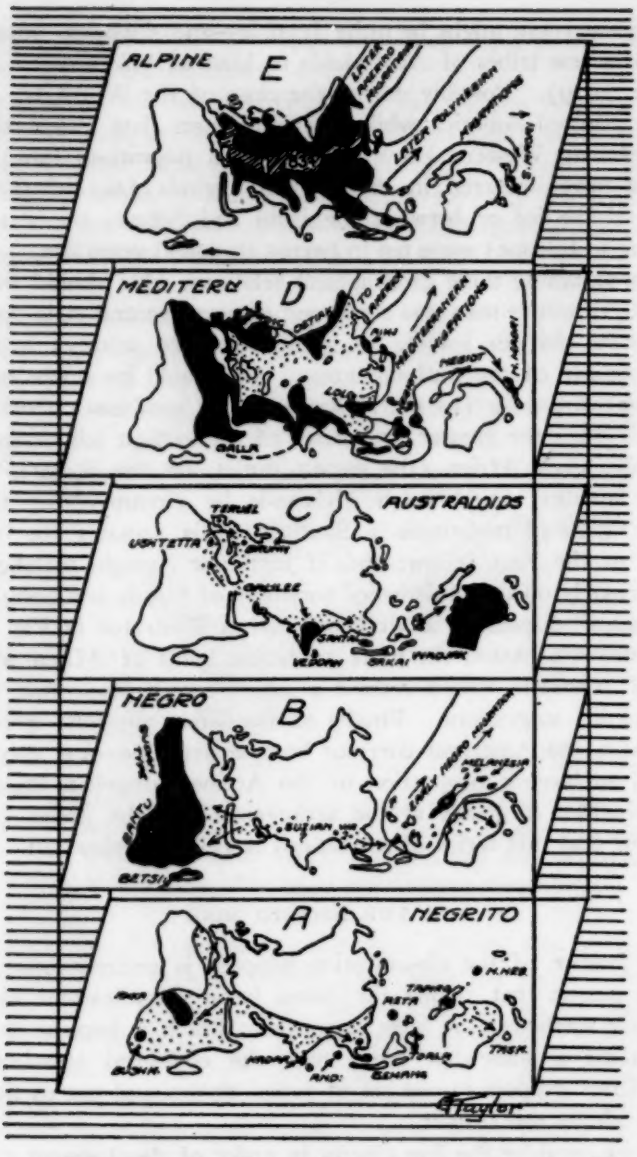

FIG. 3. FIVE STAGES IN RACIAL MIGRATIONS IN THE OLD WORLD, EACH REPRESENTING A SEPARATE MAJOR RACE. Black areas show present habitats. Dotted areas are probable early habitats. The lowest race in the diagram was the first differentiated, the highest was the latest.

temporaneous with Neandertal man (Fig. 6), cannot be claimed as proven, but seems to be more in accord with the facts than the other two suggestions. The writer has shown (1934) by means of his "ethnographs" (which correlate five important physical criteria) that the brakeph negritoes of the Congo Forest have little in common with the surrounding dokeph negroes; and the same is true of the Tapiro negritoes of New Guinea and the surrounding negroes. Yet the two far-distant negrito types very closely resemble each other (Fig. 3A). The only link between negrito and Alpine is the rather broad head of the former. In no other respect are they alike, and the writer cannot see any evidence in the general plan of racial migration which would remove the negritoes so far from all Alpines—if they were really an off-shoot of the latter. Similarly in Luzon (and in the tip of India, if recent research is correct) we find numbers of Negritoes with *no adjacent Negroes* from which to derive them!

VI. NEGROES AND NEANDERTALS

All anthropologists adopt the negro as one of their major classes (Fig. 3B). It is almost the only point of general accord. But the present writer has been endeavoring for many years to develop a reasonable theory of negro origins. Are there any relics of the ancestors of the negroes? Has their hot environment any bearing on their evolution? It is logical to expect to find some clues to their ancestry in the 'strata' underlying the relics of the present negro races in Africa, or below the Mediterranean race in Europe, Africa, and Asia.

These occur even in Asia, for Guha and Basu (in *Anthropos*, 1932, p. 162) mention several 'inliers' of tribes where 'crepe' hair is to be observed among the Nagas in Assam and also in Cochin. Furthermore, Mansey has described 'Melanesoid' skulls from Tonkin (*vide* von Eickstedt).

Western Europe is the only region which has been moderately well investigated as regards Paleolithic times. Here we find an almost universal 'stratum' characterised by Neandertal man, followed by Cromagnon, Combe Capelle, and Grimaldi man. Not many years ago it was customary to state that Neandertal man had died out, and that no living races had descended from him. The writer believes that later evidence is disproving this statement. In the first place, Neandertal man seems to have been a distinctly variable person.

The skull from Ehringsdorf (1925), although dating from Pre-Wurm days, had a loftier vault, thinner walls and a more vertical forehead than many later Neandertal types. In Keith's words (1931) already he approached modern man in these respects. One of the most primitive skulls of all comes from Broken Hill, Rhodesia—yet Smith Woodward links it with the Australoids. At Predmost (Moravia) twenty skeletons of Aurignacian culture are described by Keith as having large heads, with palates rivalling the Australoid, and in their long, high skulls reminding one of the 'negroid features of the Combe Capelle type.' The Galilee skull (Keith, 1931) also exhibits features linking Australoid and negro skulls to Neandertal, especially as regards the frontal bones and the height of the vault. Sarasin (1924) is emphatic that living negroes from New Caledonia as regards the orbit, jaw, nose and humerus are *more primitive* than the Neandertal type (1924).

Von Eickstedt (1934) corroborates the view put forward by the writer in 1919. He states that the Aurignacians of Europe show a great similarity with recent Australoids, and the resemblance also obtains with Neandertal man, but to a less degree. In his opinion, the Aurignacians are somewhat less primitive than the Australoid, as regards prognathism, face and skull-base, but are extraordinarily alike as regards body-shape, length of skull, shape of chin, etc. In Capetown in 1929 a skull was dug up from a depth of four metres which again links the European Aurignacian type with the Australoid in von Eickstedt's opinion.

Since so many writers have demonstrated that a series linking Cromagnon to Combe Capelle and to Neandertal is gradually being discovered (cf. von Eickstedt, p. 425), there seems no good reason to doubt that Neandertal man was physically as near to the ancestor of his successors as we could reasonably expect to find in a *marginal* region. An analogy with Greenland may make this clearer. Suppose anthropologists had only evidence of a marginal colony like Greenland to help them in their reconstruction of Scandinavian history. They would find skeletons and artefacts to help them to elucidate Scandinavian history from A. D. 1000 to A. D. 1400. Then right from 1400 to 1700 (when Egede made another settlement) there was an absence of Scandinavian man and culture in Greenland. The new culture after 1700 seemed entirely dissociated from that of the early Norsemen. But elsewhere, i.e. in the cradleland (here Norway), the sequence was unbroken. So also West Europe was a marginal land receiving interrupted migrations, and the complete picture of racial and cultural evolution of Neandertal man is obviously to be sought in southern Asia, not in Western Europe.

Let us once more return to the topic of living descendants of Neandertal man. Most convincing is the description of an Australoid

woman who died only a few decades ago in Eastern Australia. Burkett and Hunter (1922) give 14 Neandertaloid features in this skull. Indeed, in the regions of the torus and bregma they notice affinity to *Pithecanthropus*! The writer believes that it is precisely because the negro was thrust into the stagnant environment of the Tropics (of Africa and Melanesia) that he preserves so many primitive features. Of course he has evolved somewhat since his early arrival in the Tropics perhaps 100,000 years ago. But meanwhile in other stimulating areas racial evolution has been much more striking and has left him far behind. His 'paired' environments (in Africa and Melanesia) are indicated in Fig. 3B and Fig. 6.

VIII. THE AUSTRALOID ZONE

The writer in 1921 in a large colored chart of nine maps showed his conclusions as to the evolution and migrations of races.[4] The relative position of Negroes and Australoids is a little difficult. In both there is a wide range of characters. Thus in Australia the writer has investigated most of the coastal regions, and here the aborigines in general are much less 'primitive' in appearance than those from the central deserts, made familiar by Spencer and Gillen's splendid books.

Apart from the hair, there is no very striking difference between the Australoids and Negroes. But hair texture is universally admitted to be of great importance—and in the Australoids it is almost universally *wavy* rather than curly, and never frizzy. This places them biologically nearer the central racial zones (Mediterranean and Alpine). It is of interest that Sarasin (1924) records that the newborn New Caledonian negro has wavy hair which is replaced after the first week or so by the usual kinky negro hair. So that kinky hair is possibly a secondary character acquired by negroid peoples.

If we turn to the ecological evidence, then it seems clear that the Australoids migrated out of Asia much later than did the Negroes. Thus Mitra (1927) writes: "India shares with Africa Proto-negroid beginnings.....and with southeast Asia the *superimposition on them* of Proto-Australoid elements." There are now no negroes or negritoes on the mainland except in Perak (and perhaps in the tip of India). But there are millions of Australoids (the so-called Pre-Dravidian tribes) in the eastern hills of the Deccan in India and in

[4] In this paper he used the word "Mousterian" as a general term for races like the Australoid. But it seems better to drop this term.

Ceylon. So that we may surely say that their less marginal position agrees with the hair-character, and places the 'wavy' Australoids a little higher than the 'frizzy' Negroes of Africa or Oceania.

My suggestion is that a Neandertaloid type lived in southern Asia and gave rise to the negroes far back in the Pleistocene—perhaps in the Gunz-Mindel Interglacial (Fig. 6). The Mindel Ice Age drove most of them to the southeast—whence later they reached Africa.[5] Fewer went to the southeast and so ultimately gained Papua and Melanesia. The Semang of Perak and possibly some tribes in Assam support this hypothesis. It is little use speculating as to change in hair character which probably now developed in the cradleland, but I picture the next migration as consisting of Australoids—most of whom went into India or to the southeast and so reached Australia. Possibly their cradleland was farther to the east in Asia than was that of the negroes.

In Upper Tonkin 17 skulls of Australoids akin to those found in the Aurignacian in Europe are mentioned by von Eickstedt (1934). Many of the people living in Western Europe about B. C. 20,000 were very like the Australoids (Taylor, 1933); and Sir Harry Johnston (1923) draws attention to the Australoid appearance of the Ushtettas still living in the mountains of Algeria. It seems likely that some Australoids reached America in one of the Interglacials—probably the Riss-Wurm Interglacial. The Punin skull from Ecuador is described by Sullivan (1925) as showing a strong resemblance to Australian skulls. So also the rather numerous skulls from Lagoa Santa, Bogota, Coronel, and Patagonia, described by Verneau (1924) and others, probably represent descendants of the early Australoid migration. The Qurungua type described by Wegner (1931) from lower Bolivia is probably a living representative of this early migration.

VIII. THE MEDITERRANEAN ZONE

The next zone consists of the Mediterranean type with its variant, the Nordic (Fig. 3D). Buxton (1928) links together the Proto-Nordics of north Asia (Turkoman and Ainu) with the Australoids of India as forming one group—the Primitive Cymotrichous. While the present writer prefers to separate the Australoids as an earlier zone, he agrees that the Nordics could readily have evolved in central Asia from the Australoid type. Perhaps the Todas of India and Ainu of Japan are survivors of this peculiarly hairy, dokeph type—but with

[5]Somewhat doubtful 'inliers' of negroid traces have been described from Susa (Persia) and S. E. Arabia, (Taylor, 1921).

noses much more leptorhine than most Australoids. (The writer [1926] has, however, examined a number of full-blood aborigines in northwest Australia whose noses could fairly be described as leptorhine.)

Many writers since the time of Sergi (1901) have linked the Nordic and Mediterranean. Sergi considered the Nordics as 'bleached' Mediterraneans who had moved from Africa into the Baltic region. It seems, however, more likely that Siberia was their homeland (Taylor, 1921) in view of the kurgan relics and the similarity between the Nordic and Siberian cultures. I have long suggested that a dokeph race with wavy hair, developing (say) in Turkestan, might split into two migrations. One slowly passes through hot, arid lands to North Africa and this evironment 'selects' a dark, slender type, the Mediterranean race proper. The northern migration halts for several millenia in Siberia and then slowly moves to the Baltic. This cold, dry environment picks out the blonder, hairy types, and ultimately the taller Nordic race is differentiated.

It is perhaps significant that the blood indices of the Nordics resemble those of the Mediterranean on the one hand and the Australoids on the other (Taylor, 1930), and are very different from those of the Alpine race or negroes. On the other hand, the Alpine and 'Mongolian' blood indices are much the same, thus supporting the writer's views as to their close kinship.

As regards the origin, status and migrations of the Mediterranean group as a whole, there is little controversy. Their migrations can be traced back towards southern Asia; both from the European and African 'wings' on the west, and from the American and Indonesian wings on the east. There is no break in the centre, as in the case of the negro and Australoid zones, for India contains many representatives of this race. Indeed, it extends all round the margins of Asia, for there are many tribes of this type still surviving in the rugged ranges of South China where they have not yet been overwhelmed by the Alpine-Mongolian flood. The zone is more broken along the east coast of Eurasia than on the west—and the shattered tribes from this area are to be found in Micronesia, and constitute what Dixon calls the Caspian migration into Polynesia and America. Heine-Geldern (1932) places the cradleland of the allied Austronesian tribes in Yunnan whence they spread through the East Indies.

In India, as Mitra (1923) points out, there are clearly several distinct migrations of the Mediterranean Race. First came the early

Dravidian-speakers—probably tribes akin to the Ethiopians of northeast Africa. Their descendants are the Kurumbas of the south, and possibly the folk who built Mohenjo-daro. They may have been in control in India from B. C. 5000 to the invasion of the Aryan-speakers from the northwest. The latter were at first mainly Nordic and Mediterranean, and perhaps date as far back as B. C. 2500. Later came further invasions from the northwest which consisted largely of Alpine tribes, and these conquered the folk in the main river-corridors, i.e. down the Indus and Ganges (Taylor, 1927).

In 1919, disagreeing with Perry's deductions, I stated that these Mediterranean tribes "migrated from the Arab-Persian region and erected Megalithic monuments in Turkestan, Persia, North Africa, North India, and the East Indies." Mitra (in 1927) corroborates this view as follows: "A migration from Central Asia brought about.....an Indian-Erythrean complex which saw the rise of the huge countless funerary monuments in the Deccan as well as in Egypt."

IX. THE ALPINE-MONGOLIAN ZONE

The most popular classification of races as regards Eurasia seems to be indicated by a line running from Lapland to Burmah, which is given in Fig. 4 (Color map). The writer cannot understand how this division between the so-called Caucasian and the so-called Mongolian has persisted so long, presumably from the time of Cuvier in 1820. Many authors (e.g. Ripley) object strongly to the term Caucasian; and to the writer the only common character of the nations living in the so-called Caucasian moiety of Eurasia is that they nearly all speak Indo-Aryan tongues. But this use of language as a primary guide to race has long been given up elsewhere.

Let us, however, use "as many traits as possible," as Kroeber advises us (see Introduction). In Fig. 4 I show the main features as given in Biasutti's atlas of anthropological criteria. If we consider skin color, we find that the isopleths of color have nothing in common with the reputed major racial division (shown by the heavy black line). The Olive complexion is equally common on both sides, as also is the next grade of color, Light Brown. Head Index may be considered next, and here again the isopleths clearly run at right angles to the reputed race boundary—which to the ecologist means that they have little or nothing in common. Consider Facial Breadth (in the third map) and we see that Broad faces are characteristic of the Eurasian peoples as a whole—there is no division here either, along

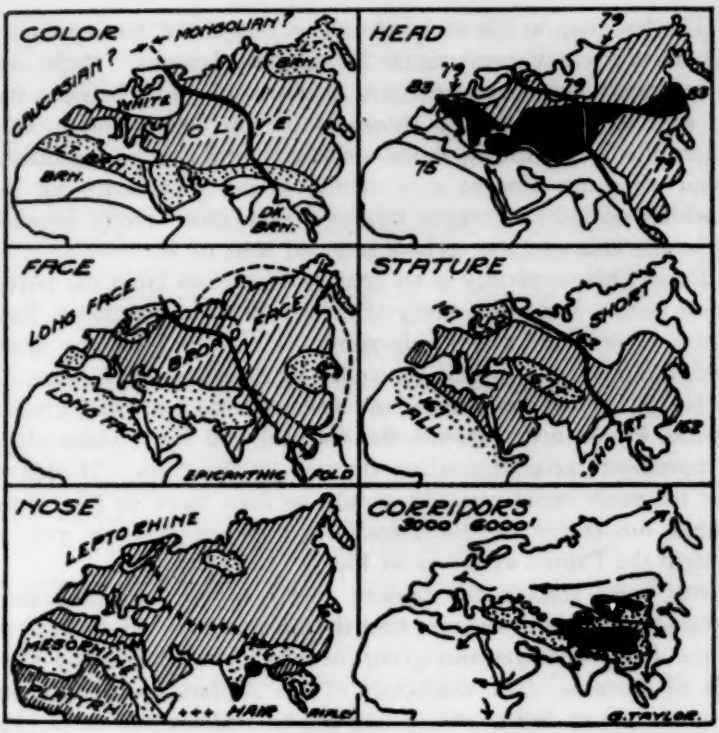

FIG. 4. MAPS CHARTING THE DISTRIBUTION OF COLOR, HEAD INDEX, FACE INDEX, STATURE AND NASAL INDEX. No support for the division of the peoples of Eurasia into Caucasian and Mongolian can be derived from these maps, which are taken from Biasutti or Ripley. Note also that the corridors of migration cross the so-called division.

the reputed boundary. So also Stature gives us no data to support this division, and Nasal Index has little bearing on it, since Biasutti labels all the Eurasian region (except the southeast) as Leptorhine. Only in Biasutti's map of hair texture is there some justification for this division for the straight-haired folks are in general to the east of the reputed boundary and the wavy-haired to the west. (See the map of Nasal Index). Kroeber, however, assigns all the straight-haired peoples of central Asia to the Caucasian,[6] while Ripley *links* Alpines and Mongols in his chart of Hair distribution.

[6]Minor differences like 'shovel-teeth' and the 'epicanthic folds' are surely not important enough to isolate the Mongols as a major race.

The last map in the series shows us that racial history lends little support to these Caucasians or Mongol subdivisions. Right through historic times peoples and cultures have passed freely between the east and west of central Asia as shown by the two long arrows. We may be sure that in prehistoric times—especially in the very long interglacial period when the climates were neither so dry in summer nor so cold in winter—primitive peoples migrated even more freely between the Turkestan area and the regions east and west of it.

Early Chinese history is an account of thrusts from the northwest. Indian history is the same story of thrusts from the northwest. Egyptian history records the major migrations as coming from the northeast. European history is entirely controlled by thrusts from the east. There can be little doubt that stresses and strains in the heart of Eurasia—one deduces in the area between the Caspian and the Pamirs—have set in movement racial migrations throughout the Ages. If this be so, then the main racial isopleths should be lines more or less concentric around the centre of disturbance—and cannot possibly run almost through the Pamirs as shown in Fig. 4 (Color map).

For these reasons the present writer in 1919 adopted the term Alpine-Mongolian to indicate that the Mongol type was only a variant of the fairly homogeneous group of peoples which occupy the main bulk of Eurasia. The characters of the Alpines are indeed summed up in the set of five charts. They are all brakeph (80 to 90), almost all olive in color, all broad face, of medium stature, and with leptorhine noses. The hair is on the whole wavy in the west and straight in the east, but is never curly—much less frizzy. They occupy the centre of the series of approximately concentric racial zones—and for reasons already given represent the latest development of the human race. Man has evolved in the common cradleland of most of the mammals—the heart of Eurasia—owing to the fact that the climatic stimulus right through later Tertiary times has been the most favorable for producing mammalian evolution. It does not seem to occur to most anthropologists that the cradleland of the higher mammals would *a priori* be the most likely place for the highest type of all (man) to originate and to *continue evolving.*

X. CHANGES IN CLASSIFICATION

A glance at Fig. 5 will show how the writer's Zones and Strata Classification differs from the more orthodox form, which is usually

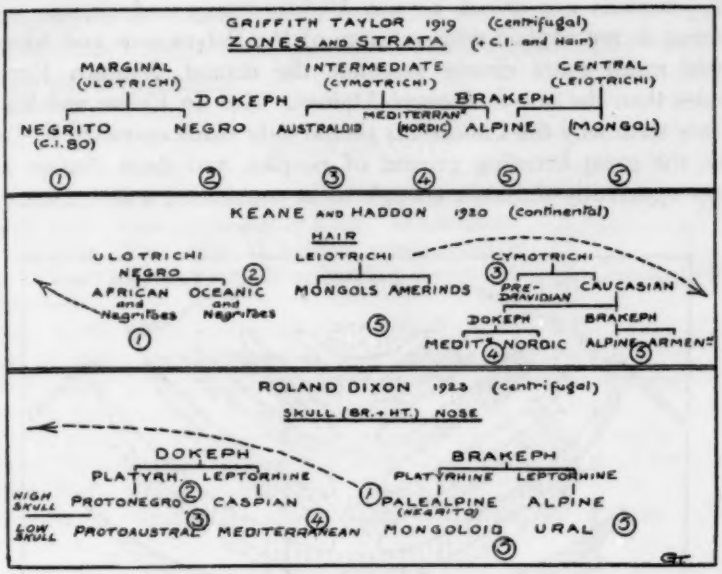

FIG. 5. COMPARATIVE OUTLINES OF RACIAL CLASSIFICATIONS, SHOWING THE MAIN CRITERIA ADOPTED BY KEANE AND HADDON, ROLAND DIXON AND THE PRESENT WRITER.

like that used by Keane and Haddon. The preceding discussion has shown that a major feature in the differentiation of races is their migration away from the centre of Eurasia, in effect, it is *centrifugal*. The racial history (as based on the zones and strata) is a very important feature in the classification, but head index, hair and other features are made use of as criteria also. As a result we obtain five races, of which Negro, Mediterranean and Alpine are the most significant, while Negrito and Australoid are less so.

In Fig. 5 the five major races in the writer's classification are shown by the numerals. These are repeated in the two lower classifications. The broken lines show the major changes necessary to bring the latter into approximate agreement with the Zones and Strata Classification. In Fig. 6 the development of twin (or paired) habitats due to the thrusts outward from Asia is charted as a Racial Tree.

In Keane and Haddon's Classification we find still persisting the Caucasian, Mongol and Negro groups of Cuvier. Hair is used as the major criterion. Head Index is given no weight at all, for Mongols

and Amerinds are linked, as are Mediterranean and Alpine. These schemes do not explain why so many of the Polynesians and Amerinds should much more closely resemble the distant Western European peoples than the nearer Mongol-Alpines. Nor do Keane and his supporters state why the Caucasians should only reach eastward to Central Asia, the great breeding ground of peoples, and there change into a group apparently different enough to be considered a new race.

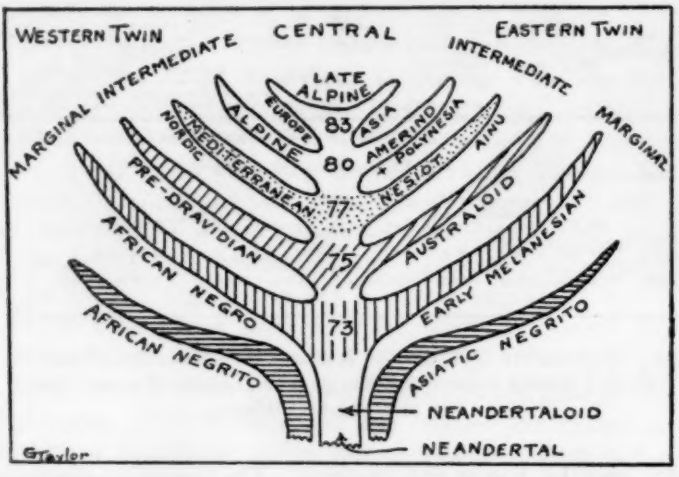

FIG. 6. THE RACIAL "TREE" SHOWING THE RELATIONS OF THE FIVE RACES. The "twin distribution" is most striking, and indicates a common cradleland for all the races. The Negritoes evolved from a non-Neandertal type, the negroes and the other races from a Neandertaloid. The figures are head indices. (From Atlas of Environment and Race, 1933).

Dixon (1923) has discarded many of the earlier concepts and developed a scheme (based on head and nose indices) which in many ways corroborates the writer's deductions (Fig. 5). Indeed, he goes further, for he finds the major racial groups penetrating by centrifugal movement into *all* the continents. But his linking of the earliest or negrito stock with the latest Alpine stock seems to the writer to be contrary to all the evidence. Moreover, he, like most other anthropologists (excluding Ripley), perhaps does not lay enough stress on environmental factors in determining migrations. In fact, he is not much concerned with *causes*. The writer knows of no recent

anthropologist but himself who has applied the lessons of ecology and of mammalian biology to the question of the differentiation of man—the greatest of the mammals.

BIBLIOGRAPHY

BIASUTTI, R. 1912. Antropogeografia Generale. *Mem. Geog., Florence.*

BOAS, F. 1911. Changes in Bodily Form. *Washington.*

———. 1913. Head form of Italians. *Amer. Anthrop.*

BURKITT and HUNTER. 1922. Neandertaloid Australian skull. *Journ. Anatomy, Cambridge.*

BUXTON, L. D. 1925. Peoples of Asia. (Book) *New York.*

DIXON, R. 1923. Racial History of Man. (Book) *New York.*

HEINE-GELDERN, R. 1932. Cradle of Austronesia. *Anthropos, Vienna.*

JOHNSTON, HARRY. 1923. Story of My Life. (Book) *London.*

KEITH, A. 1931. New Discoveries Relating to Man. (Book) *London.*

KOEPPEN, W. 1932. Age of Man in Europe. *Anthropos* (p. 955), *Vienna.*

KROEBER, A. L. 1923. Anthropology. (Book) *New York.*

MACALISTER, A. Quoted by Keane, 1920. Man Past and Present. (Book) *Cambridge.*

MATTHEW, W. D. 1915. Evolution and climate. *Ann. Acad. Science, New York.*

MITRA, P. 1927. Prehistoric India. (Book) *Calcutta.*

PERRY, W. J. 1923. Children of the Sun. (Book) *London.*

RIPLEY, W. Z. 1900. Races of Europe. (Book) *London.*

RIVET, P. 1925. Les origines de l'homme Américain. *L'Anthropologie, Paris.*

SARASIN, F. 1924. New Caledonian Negroes. *L'Anthropologie, Paris.*

———. 1925. Hair of New Caledonians. *L'Anthropologie, Paris.*

SERGI, G. 1901. The Mediterranean Race. (Book) *London.*

SULLIVAN and HELLMAN. 1925. The Punin calvarium. *Amer. Mus. Nat. Hist., New York.*

TAYLOR, GRIFFITH. 1919. Climatic cycles and evolution. *Geog. Review, New York.*

———. 1921. Evolution of race and language. *Geog. Rev., New York.*

———. 1924. Kamilaroi and white. *Roy. Soc., Sydney, Australia.*

———. 1926. Variation among Australian Aborigines. *Sci. Congress, Tokyo.*

———. 1927. Environment and Race. (Book) *Univ. of Oxford Press.* (Japanese edition, 1931.)

———. 1930. Racial migration zones. HUMAN BIOLOGY, *Baltimore.*

———. 1931. Nordic and Alpine races. *Amer. Jnl. Sociology, Chicago.*

———. 1933. Atlas of Environment and Race. (Book) *University of Chicago.*

———. 1934. Ecological basis of anthropology. *Ecology, Chicago.*

———. 1936. Environment and Nation. (Book) *University of Toronto.*

VENN, J. 1889. Anthropometry at Cambridge. *J. Anthr. Inst., London.*

VERNEAU, R. 1924. Crânes d'Indiens de la Colombie. *L'Anthropologie, Paris.*

VON EICKSTEDT, E. 1934. Rassenkunde und Rassengeschichte. (Book) Stuttgart.

WEGNER, R. N. 1931. Zum Sonnentor durch altes Indianerland. *Darmstadt.*

THE RELATIONSHIP BETWEEN BODILY AND GASTRIC ACTIVITY OF NEWBORN INFANTS

I. CORRELATION AND INFLUENCE OF TIME SINCE FEEDING

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STUDIES of general bodily activity of newborn infants by Szymanski (9), Irwin (4, 5), and others have shown that infants are least active just after meal periods, and that the increment in activity after eating is greater the greater the time elapsed since feeding (4). These findings suggest that the nutritional state of the organism is closely related to its general activity. The physiology of this relationship is not clear, however.

In a review of the literature (8) the author has attempted to cover the several possibilities involved, notably the theory of Irwin (4, 5) that the increase in activity is due in large part directly to the powerful contractions of the stomach associated with "hunger." These gastric phenomena have received much attention from physiologists since the original work of Cannon (1) and of Carlson (2). Patterson (6) has studied genetic factors in the gastric motor mechanism in dogs; Carlson and Ginsburg (3), Rood Taylor (10), and Peiper and Isbert (7) have investigated gastric motor phenomena in human infants. In 1922 Wada (11) reported an experimental study of the relationship between hunger and activities in human adults, infants, and rats. She concluded that most bodily activity in her adult human subjects occurred during gastric activity, least occurring during gastric quiescence. This was true during waking, and more pronounced during sleep. This conclusion regarding infants and rats, however, was not warranted by her data, since no measurement of gastric activity was made.

Although the possibility of correlation between gastric motor phenomena and general bodily activity in infants has been exploited theoretically, there has not been experimental investigation of the problem.

It is the purpose of these experiments to elucidate the possibility of the relationship between gastric and general bodily motor activity in newborn infants, with the aim of indicating causal relationships. The material will be reported in two sections: (1) general nature of bodily and gastric activity and the relationship between them, and (2) the effect of time since feeding and of long-continued light stimulation on bodily and gastric activity.

METHOD OF EXPERIMENT

Newborn infants, during the first ten days of life, were used in all experiments.[1] The nature of the groups will be discussed in connection with each experiment.

Bodily activity was measured by means of an adaptation of the stabilimeter used in the Ohio State and Iowa laboratories. This adaptation provided for an electrical rather than mechanical transmission of movements of a small bed to a polygraph. The unit of measurement obtained was number of seconds active in any given period. A constant speed motor furnished records at a speed of 8 3/8 inches per minute, a speed considerably greater than that used in practically all experiments with gastric motility.

Two criteria were used for determination of sleeping, waking, and crying: observation by the experimenter and checking by examination of the records of breathing. Breathing during sleep was unique in its regularity (See Figure 1, A, B, C, and D), as was crying (Figure 1, E). If eyes were closed and the infant was quiet, the state was regarded as sleeping. Crying was judged by activity associated with audible forced expiration. Waking was judged negatively by counting out sleeping and crying. The greatest difficulty in judgment was between sleeping and waking. Any doubtful judgment in this respect is included as "sleep" in all calculations if regular breathing was observed.

The balloon method of Cannon (1) and of Carlson (2) was used to obtain gastric records.[2] The balloon was connected with a Marey

[1]Infants were made available for experimentation through the kindness of Dr. E. D. Plass, Professor of Obstetrics and Gynecology at the State University of Iowa, to whom the author expresses his appreciation.

[2]The author is indebted to Dr. T. L. Patterson of the Department of Physiology of the Wayne University College of Medicine, and to Dr. R. M. Collins of the State University of Iowa Department of Obstetrics and Gynecology for suggestions regarding technique of measurement of gastric motility.

tambour. A bromoform manometer was also attached, but not between the balloon and tambour. A pressure of 2 cm. bromoform was found best suited for the records desired, although because of gastric movements it was not possible to maintain this pressure constantly. Respiratory records were taken with most of the infants, by means of a pneumograph, also attached to a Marey tambour.

Although Carlson and Ginsburg (3) reported little difficulty in passing the balloon into the stomach of the infant, several of the infants in this experiment could not be induced to swallow it. No effort was made to force the balloon in any way. It appeared that most of the infant would swallow the balloon with little difficulty if patience was used by the experimenter in presenting it.

Excepting when the intensity of light was varied, as will be indicated, the infant lay on the stabilimeter within a Pratt experimental cabinet under fairly standard controlled conditions. The cabinet was relatively sound proof, and was kept at a temperature of about 86° to 88°F. A light of 15 watts was used in the cabinet, of the intensity of 2.5 foot candles at the infant's head (measured by Weston Lightmeter).

Since the infant was entirely unrestrained, excepting slightly, perhaps, by the pneumograph bag over the upper abdomen and by its shirt (most infants wore only a diaper), parts of the gastric record are confused by the mechanical effect on the balloon of bodily movements. It is possible, of course, that these bodily movements result from gastric activity in some cases. The pneumographic record served as a check on the mechanical factor involved, in that increase in thoracic pressure due to breathing and diaphragmatic action increases the abdominal pressure and thus the pressure within the balloon system. Where irregularities in the stomach curve corresponded with irregularities in the breathing curve, it was fair to assume that the gastric pressure was respiratory in origin. Usually, as we hope to show, this type of record almost always showed bodily activity also to occur. In all cases, unless regurgitory, the record was one of crying or the Moro Umklammerungs reflex or body startle.

Records were judged, after some trial of methods, as showing (1) gastric quiescence, (2) peristalsis, or (3) gastric hyperactivity. This last term is not, perhaps, entirely suitable because under this heading is included the phenomenon mentioned above: changes in the gastric record accompanied by changes in the breathing record,—regurgi-

tory crying movements and Moro Umklammerungs responses. Figure 1, A, B, C, E, and F will illustrate each of these types of activity. Gastric records of crying differ markedly from all others, as illustrated in Figure 1, E. Figure 1, D offers a comparison of gastric activity measured by the fast-moving polygraph used throughout the experiment and the simultaneous record taken on a kymograph. This was done to show the similarity between our records of "peristalsis" and those of "hunger contractions" obtained by the other workers in the field of infant gastric activity.

TABLE 1.

Gastric and Bodily Activity of Two Groups of Newborn Infants During the Third Hour Following Feeding

MEASURE	CONDITION	LIGHT: Medium (11 Boys) (6 Girls) Mean	Medium Standard Deviation	Bright (8 Boys) (5 Girls) Mean	Bright Standard Deviation
Percent					
Gastric Activity	Quiescent	37.3	19.5	21.7	12.4
	Peristaltic.....	41.0	21.0	49.7	11.9
	Hyperactivity....	21.7	14.2	28.6	8.7
Bodily Activity	Quiescent	.4	.6	.1	.2
	Peristaltic.....	.6	.8	.3	.1
	Hyperactivity....	16.7	9.0	10.5	5.9
	Total	6.0	7.5	3.0	2.4
Time	Asleep	71.8	27.5	81.1	15.9
	Awake.....	21.3	24.9	13.6	9.6
	Crying.....	6.9	14.6	5.3	9.1
Age, days		5.8	2.8	3.0	0.0
Birth Weight, Kilograms		3.6	.2	3.2	.4

RESULTS

In Table 1 are presented the significant data with respect to two groups of infants, one of seventeen studied under moderate light (2.5 ft. candles) and the other thirteen under bright light (22.0 ft. candles),

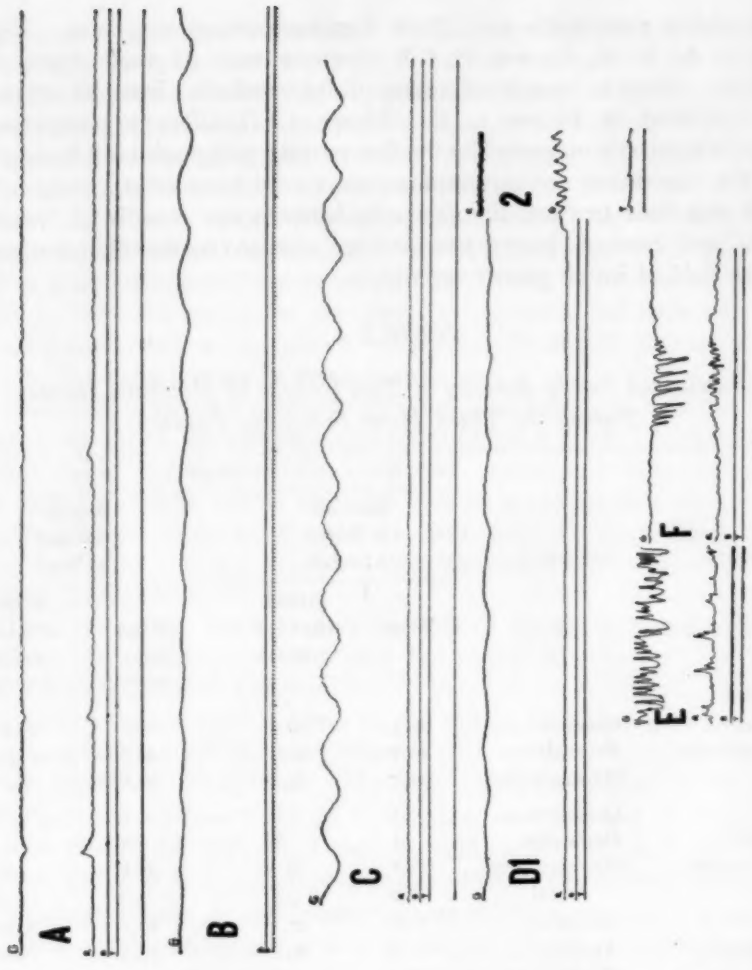

FIG. 1. RECORDS SHOWING TYPES OF GASTRIC ACTIVITY. In all Polygraph records increase in gastric pressure causes downward excursion of gastric line. Increase in pneumographic pressure causes upward excursion of respiratory line. In kymographic record (D2) increase in pressure of each system causes upward movement of line.

A. Excerpt of record 4 hours, 38.8 minutes after feeding, 12.8 minutes after start of record, showing gastric quiescence punctuated by typical Moro reflexes, involving respiratory and bodily response, and secondary gastric response probably the result of increase of thoracic pressure. Sleep throughout, as incidentally shown by regularity of breathing.

each starting approximately 2 1/2 hours after feeding and continuing for about 41 to 43 minutes until about 3 1/4 hours after feeding. It will be seen that for the two groups respectively the stomach is quiescent 37 per cent and 22 per cent of the time, peristalsis occurs 41 per cent and 50 per cent of the time, and gastric hyperactivity probably due to bodily activity occurs 22 per cent and 29 per cent of the time. The standard deviations of these averages show that there is wide variation between individuals in the amount of time spent in these types of gastric activity. The infants sleep 72 per cent and 81 per cent of the time, are awake 21 per cent and 14 per cent of the time, and are crying 7 per cent and 5 per cent of the time. During the whole period all the infants average about 6 per cent bodily activity. If, however, we calculate the activity for each type of gastric activity we find that during gastric quiescence and peristalsis activity is very low, in each case less than 1 per cent, while during gastric hyperactivity it is as high as 17 per cent and 11 per cent. A calculation of activity during crying alone gave an average of 32 per cent and 19 per cent of the time active, for the ten infants who cried.

B. Excerpt of record 2 hours, 51.7 minutes after feeding, 44.7 minutes after beginning of record. Sleep throughout. Note increasing amplitude of peristaltic waves, gradually assuming proporions of "hunger contractions." Also note complete absence of bodily activity.

C. Excerpt of record 2 hours, 43.2 minutes after feeding, 28 minutes after start of record. Sleep throughout. Note great amplitude of peristaltic waves. Definite "hunger contractions." Note absence of activity.

D1 and D2. Simultaneous records of gastric and respiratory activity, by means (D1) of polygraph run at 8 3/8 inches per minute and (D2) kymograph run at about one inch per minute. For the kymograph record a sensitive respiratory tambour and a resistant gastric manometer (bromoform) were purposely used in order in the gastric record to partial out breathing variations. The direction of pressure in the gastric system unfortunately is opposite in comparing the two records. Note in the kymograph record the great similarity of peristalsis to the "hunger contractions" noted by other workers. Record taken 2 hours, 36 minutes after feeding, three minutes after beginning of record. Infant asleep throughout.

E. Excerpt of record taken 2 hours, 59 minutes after feeding, 11 minutes after beginning of record. Typical crying record. Note here the impossibility of determining gastric activity. Note almost continuous bodily activity.

F. Record taken 5 hours, 45 minutes after feeding, 4 minutes after beginning of record. Note single, violent contractions of stomach, each concomitant with regurgitory movement. Infant awake. Bodily activity usually accompanied these movements, which come in periods, after which the child was usually quiescent.

From these results it is apparent that activity is low for newborn infants both when the stomach is quiescent and when peristalsis is in progress. This is true even when the peristalsis assumes the character of "hunger contractions." Although it is not definitely indicated in the results, it appears that the major portion of bodily activity occurs as consisting of almost unitary body startles somewhat spontaneous in character, or as of continued periods of activity as characterized by crying, etc. Regurgitation caused bodily activity in most cases. The organic cause of each of these types of activity is little understood. Slow movements associated with what has been termed "restlessness" may occur at any time, and contribute toward the slight activity present during gastric quiescence or peristalsis on the one hand and sleep on the other.

Correlations by the method of rank differences were obtained for the medium light and bright light groups. These correlations should be interpreted with caution since they were obtained on data from few cases in each group. They are, however, of sufficient reliability to be suggestive. For each group the correlations between the various significant factors appear below:

FACTORS	MEDIUM LIGHT	BRIGHT LIGHT
Bodily activity and per cent peristalsis	+.08±.16	−.64±.12
Bodily activity and per cent gastric hyperactivity	+.74±.11	+.12±.19
Per cent sleep and per cent peristalsis	−.01±.17	+.49±.15
Per cent sleep and per cent gastric hyperactivity	−.64±.12	−.60±.13
Bodily activity and per cent sleep	−.79±.07	−.46±.15

These coefficients bear out the same conclusions: that bodily activity is predominantly absent during peristalsis and gastric quiescence, as well as sleep, and is characterized by definite changes in gastric pressure as the result of regurgitory movements, or of sudden respiratory movements associated with the body startle or with crying. For these types of general activity no organic etiology can as yet be posited.

AGE RELATIONSHIPS

A correlation by the method of rank differences between age and bodily and gastric activity, on the group of seventeen infants under medium light, gave the following coefficients:

Peristalsis and age	−.07±.18
Gastric hyperactivity and age	+.06±.17
Age and bodily activity	+.53±.12

These would indicate that there is, within the age range of the first ten days of life, no relationship between age and bodily or gastric activity. The results for one male infant, studied during the third hour after feeding, at two, six, and eight days of age, are as follows:

AGE, DAYS	PERISTALSIS	GASTRIC HYPERACTIVITY	BODILY ACTIVITY	SLEEP, MINUTES
2	48.4	26.7	5.8	58.7
6	76.9	11.1	2.9	51.3
8	37.0	9.5	1.8	100.0
Range	39.9	17.2	4.0	41.3
Average	41.0	21.7	6.0	71.8
Group Average	21.0	14.2	7.5	27.5

No definite age trend for this individual can be noted except that in bodily activity it was slightly more variable than the group as a whole, if its range is compared with the standard deviation of the group. The increase in amount of sleeping is probably of no significance, though it is possible that the infant may have become adapted to the cabinet and general experimental set-up.

DIFFERENCES BETWEEN SEXES AND TYPES OF FEEDING

Male infants were found to be slightly more active and to give slightly more gastric hyperactivity than female infants, but the differences were not sufficiently large to be significant. No differences were found between sexes in amount of peristalsis, or in amount of sleep.

In the second series (bright light) three infants who received artifical feeding supplementarily to breast feeding showed, when compared with the remaining breast-fed infants of that group, slightly less peristalsis and sleep, and more bodily activity and gastric hyperactivity. Differences were not sizable, however. Two infants in the first series (medium light) differed from the averages of the remaining breast-fed infants in their group in opposite ways. One gave no peristalsis, and very little gastric hyperactivity and bodily activity. The stomach was quiescent almost the entire period, while the infant slept 87 per cent of the time. The other infant was very little more active than the wholly breast-fed infants of his group, and thus out of keeping with the other breast-fed and bottle-fed infants. Peristalsis occurred for

a greater period, although like the other partly bottle-fed infants he slept less.

Coefficients of correlation by the method of rank differences between birth weight and peristalsis, and gastric hyperactivity and bodily activity were low. When age was held constant, as in the bright light series composed only of three-day-old infants, there was a slight positive relationship between amount of peristalsis and birth weight ($r = +.32 \pm .17$), and a slight negative relationship between body weight and gastric hyperactivity ($r = -.48 \pm .15$). No relationship between bodily activity and birth weight was found, thus in agreement with the findings of Irwin.[3] Strangely enough, if age is not held constant, as in the medium light group, the amount of peristalsis varies negatively with birth weight. Yet, we have seen that there is no relationship between age and peristalsis.

EFFECT OF THE GASTRIC BALLOON

Control groups of infants were studied for comparison with experimental groups for two reasons: (1) in order to determine whether or not the increase in activity during the time since feeding was common to these infants as it was to the infants used by Irwin (4, 5) and, (2) to determine whether or not the presence of the balloon in the stomach of the infants might affect the degree of bodily activity exhibited.

For these reasons, two control groups were used each under medium light. The first was a group of fifteen infants studied immediately after feeding, the second a group of sixteen at about the same time after feeding as that at which the experimental group was studied: namely, two and one-half hours. Activity records and time spent in sleeping and waking were noted. Results comparing the activity and amount of sleep of each group were as follows:

GROUP	TIME AFTER FEEDING	NUMBER OF INFANTS	PER CENT SLEEP	PER CENT CRY	ACTIVITY
Control	First hour	15	77.5	5.9	2.4
Control	Third hour	16	48.1	22.2	15.7
Experimental	Third hour	17	71.8	6.9	6.0

[3]Irwin, Orvis C.: The relation of bodily motility to some physical traits. *J. Exper. Educ.*, 1932-1933, 1, 140-143.

An analysis of these data statistically showed that the third hour control group was significantly more active than the first hour control, and that it slept significantly less and cried more. In this respect they are similar to Irwin's (4, 5) infants. On the other hand, the experimental infants, with the gastric balloon, did not differ significantly from the first hour control group in any way. They were, further, very similar to the just-fed infants in sleeping more, crying less, and moving less than the third hour control group.

One cannot avoid concluding generally, therefore, that infants with the gastric balloon are less active than those without the balloon. For this, three explanations are possible. First, the experimental infants may show the result of fatigue consequent to passing the balloon, which in some cases required a fairly long period of constant stimulation to the regurgitory reflexogenous zone in the back of the throat. That this explanation does not wholly suffice is shown by the fact that infants in the last hour control group who had had the balloon offered to them equally as arduously were equally as active as the whole control group, as the following data will show:

THIRD HOUR CONTROL INFANTS	NUMBER OF INFANTS	PER CENT SLEEP	PER CENT CRY	ACTIVITY
Whole group	16	48.1	22.2	15.7
Tried balloon	6	46.1	20.8	13.1

Secondly, it might be argued that the infants who finally accepted the balloon did so because they were peculiarly less irritable and more prone to sleep, etc., than were the infants who refused it entirely. This may, indeed, be possible, but such violent activity was shown by certain of the infants in the gastric series that they, at least, must be exceptions to this possibility. Finally, the slightly distended balloon may have an inhibitory effect on bodily activity. That this may be the case is suggested from the similarity of results for bodily activity and for sleeping in the experimental and just-fed groups. It is entirely possible that the slight pressure within the balloon required for satisfactory records of gastric activity may be in the nature of the pressure coincident with food in the stomach, and that this pressure in each case actually inhibits bodily activity, waking, and crying.

In this connection it is interesting to recall that in the literature on stomach contractions observers have frequently noted that after

insertion of the balloon the animal quieted down and went to sleep (6, 3).

TIME SINCE FEEDING

In order to study the effect of "hunger" on both bodily and gastric activity in newborn infants, comparisons were made between a just-fed control group and several infants grouped according to the time since feeding at which they were studied. Arrangements were made at the hospital for a group of five infants to miss one feeding of the four hour schedule, so that seven and one-half hours elapsed before the next feeding. These infants were studied at the times listed below:

GROUP	NUMBER	AGE, DAYS	PERIOD (MINUTES) STARTING TIME	LENGTH	MEDIAN TIME
Control*	15	4.0	000.0	30.2	000.0
Series I	17	5.8	124.0	40.9	144.5
Series II	1	7.0	256.0	76.0	294.0
Series III	2	7.0	341.5	32.0	357.5
Series IV	5	7.0	378.5	57.1	407.0

*No gastric balloon in this group.

For the sake of convenience in designating the groups we shall call them the first, third, fifth, sixth, and seventh hour groups.

Below appear the data for amount of peristalsis, gastric hyperactivity, bodily activity, and sleep for each of the groups. It should be kept in mind that the fifth and sixth hour groups are composed of one and two infants respectively; hence they give only a rough indication of what might be expected of a larger group.

TIME STUDIED	PER CENT PERISTALSIS	PER CENT GASTRIC HYPERACTIVITY	BODILY ACTIVITY	PER CENT SLEEP
First hour	00.0	00.0	2.4	77.5
Third hour	41.0	21.7	6.0	71.8
Fifth hour	28.4	17.1	2.4	96.9
Sixth hour	58.8	22.0	1.9	95.0
Seventh hour	71.1	22.3	2.5	85.1

Statistical analysis of the differences between these groups showed a slightly significant increase in bodily activity in the third over the

first hour, but that bodily activity is as low in the seventh hour as in the first. Sleep is somewhat greater in the seventh hour than in the first or third. Hyperactivity of the stomach associated with respiratory changes remains practically constant over the whole period. The most significant change over the seven hour period is in amount of time peristalsis occurs in the stomach. It appears to increase from 41 per cent at the third hour to 71 per cent in the seventh hour. This corresponds with the findings of Carlson, *et al.*, that periods of "hunger contractions" increase in frequency (and, we noted, in strength), as time elapses since feeding. They appear increasingly to stimulate the contractions obtained by earlier workers during fasting. On the other hand, the infants in this study at no time showed "practically continuous" gastric activity, as young animals have been described to exhibit by other workers (6, 3).

CONCLUSIONS

From this phase of the study we may conclude that

1. Gastric activity of peristaltic type increases definitely with time since feeding.

2. Bodily activity appears to increase similarly, but this increase is not apparent when the gastric balloon is inserted. This phenomenon may be the result of an inhibitory effect of the balloon and its pressure within the stomach. It is possible that the mild pressure used in this experiment may be somewhat similar to that exerted by a meal and thus quieting to the infant. A parallel to the inhibition of bodily activity by the balloon is not apparent, however, so far as gastric activity is concerned, for the increment in peristaltic activity occurs when the balloon is present.

3. Though there are wide differences between infants and in the individual infant on different days in gastric and bodily activity, these differences do not appear referable to age, sex, type of feeding or physical status as indicated by birth weight.

4. The increased activity shown by the infant who is hungry is not referable to stimuli arising from the motor activity of the stomach. During the type of gastric activity characteristic of the hungry infant—strong peristalsis—there is no more bodily activity than during gastric quiescence.

Probably both the increasing peristalsis and the increasing bodily activity of hunger are responses (the former relatively specific, the latter general) to stimuli concomitant with changes in the blood stream.

It is definitely shown, however, that whereas the empty stomach seems not to facilitate bodily activity, the slightly distended stomach inhibits it.

ACKNOWLEDGMENT

To Dr. Orvis C. Irwin the author owes much for his guidance throughout, since the experiment owed its inception and completion to his continued interest.

REFERENCES

1. CANNON, W. B.: The Mechanical Factors of Digestion. *London*: Arnold, 1911. Pp. xi, 227.
2. CARLSON, ANTON JULIUS: The Control of Hunger in Health and Disease. *Chicago, Ill.*: University of Chicago Press, 1916. Pp. vii, 319.
3. CARLSON, A. J., and GINSBURG, H.: Contributions to the physiology of the stomach: XXIV. The tonus and hunger contractions of the stomach of the new-born. *Amer. J. Physiol.*, 1915, 38, 29-32.
4. IRWIN, ORVIS C.: The amount and nature of activities of newborn infants under constant external stimulating conditions during the first ten days of life. *Genet. Psychol. Monog.*, 1930, 8, 1-92.
5. IRWIN, ORVIS C.: The distribution of the amount of motility in young infants between two nursing periods. *J. Comp. Psychol.*, 1932, 14, 429-445.
6. PATTERSON, THOMAS L.: Comparative physiology of the gastric hunger mechanism. *Annals N. Y. Acad. Sci.*, 1933, 34, 55-284.
7. PEIPER, ALBRECHT, and ISBERT, HEIMO: Bewegungen des Magendarmkanals im Säuglingsalter. 1. Der Magen. *Jahrb. f. Kinderh.*, 1928, 119, 291-299.
8. RICHARDS, T. W.: The importance of hunger in the bodily activity of the neonate. Submitted for publication in the *Psychological Bulletin*.
9. SZYMANSKI, J. S.: Versuche über Aktivität und Ruhe bei Säuglingen. *Pflügers Archiv für die Gesamte Physiologie*, 1918, 172, 424-429.
10. TAYLOR, ROOD: Hunger in the infant. *Amer. J. Dis. Child.*, 1917, 14, 233-257.
11. WADA, TOMI: An experimental study of hunger in its relation to activity. *Arch. Psychol.*, 1922, 8, No. 57, 1-65.

THE RELATIONSHIP BETWEEN BODILY AND GASTRIC ACTIVITY OF NEWBORN INFANTS

II. SIMULTANEOUS VARIATIONS IN THE BODILY AND GASTRIC ACTIVITY OF NEWBORN INFANTS UNDER LONG-CONTINUED LIGHT STIMULATION

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IT HAS been shown in an earlier report (7) that bodily activity of newborn infants increases definitely with time since feeding, as Irwin had found earlier (2) (3), and that the phenomenon of gastric peristalsis increases likewise, as Carlson and Ginsburg (1), Rood Taylor (8), Peiper and Isbert (5) have shown. However, when the gastric balloon was used to study the simultaneity of these increments, it was found that the presence of the balloon resulted in such a lowering of activity that the infant several hours after feeding with the balloon in its stomach was more like a just-fed infant than like a hungry one. Bodily activity during the periods of gastric peristalsis or hunger contractions was no greater than during gastric quiescence, and the amount of time spent in "spontaneous" activity was about the same at any time since feeding if the gastric balloon was present.

Weiss (10) showed that the bodily activity of infants was inhibited by long-continued light stimulation roughly in inverse proportion to the intensity of light. Patterson (4) found that the gastric activity of bull-frogs was inhibited by crude increases of light. This was not true for sound stimulation.

On the basis of these facts, it was felt that a demonstration of whether or not light was thus inhibitory to gastric as well as to bodily activity might shed light on any causal relationship that might exist between bodily and gastric activity. The literature regarding this problem has been reviewed elsewhere in some detail by the author (6).

For comparison of groups under different intensities of light, primarily two groups were used, one of seventeen infants under the light of a 15 watt bulb, with an intensity of 2.5 foot candles at the infant's head, the "medium light" group, and the other of thirteen infants under the light of a 100 watt bulb, with an intensity at the infant's head of 22.5 foot candles. Calibrations of intensity were made by means of a Weston lightmeter. The infants in each group were newborns, studied during the lying-in period. Technique for measurement and calculation of bodily and gastric activity has been described in the preceding paper. Age, sex, weight, gastric and bodily activity, and sleep and crying of each group are presented in Table 1. In Table 1 are presented also the data for a group under dark. This

TABLE 1

Age, Sex, Weight, Gastric and Bodily Activity, Sleep and Crying of Each Group

MEASURE	FOOT CANDLES				DARK	
	2.5 (11 Boys) (6 Girls)		22.0 (8 Boys) (5 Girls)		(4 Boys) (2 Girls)	
	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
Age, Days	5.8	2.8	3.0	0.0	3.0	0.0
Median Time After Feeding (Minutes)	154	...	147	...	183	...
Per Cent						
Peristalsis	41.0	21.0	49.7	11.9	78.7	20.5
Gastric Hyperactivity	21.7	14.2	28.6	8.7	14.8	15.4
Bodily Activity	6.0	7.5	3.0	2.4	2.3	4.6
Sleep	71.8	27.5	81.1	15.9	...	...
Body Weight	3.6	.2	3.2	.4	3.3	.2

group was obtained by removing all light from the cabinet directly after the bright light experiment in the case of six infants, and for from four to twelve minutes. Hence, it is not a strictly comparable group, since the first portion of the dark period would naturally involve factors of dark adaptation, etc.

BRIGHT AND MEDIUM LIGHT GROUPS

Statistical analysis of differences between the averages in amounts of peristalsis, gastric hyperactivity, bodily activity, and sleep shows that the bright light group does not differ markedly from the medium light group in any particular. There is a tendency, however, for the bright light group to be less active, to show slightly more hyperactivity of the stomach associated with changes in respiratory pressure, more peristalsis, and more sleep. These last three increases, associated as they are with decreased bodily activity, would appear in some measure to indicate an inhibitory effect of light. We have shown in an earlier paper that peristalsis,—even that characterizing the "hunger contractions" of Carlson, *et al.*,—is associated with lowered bodily activity and increased sleep. The increase in gastric hyperactivity under increased light, paralleling the decrease in crying, is difficult of explanation. Regurgitation is infrequent in sleep, and crying is slight in the bright light group. The increase in gastric hyperactivity may be the result of an increase in body startles, or Moro Umklammerungs reflexes, which may be more frequent in sleep and in the semi-sleeping state. It is believed that increasing the number of cases in each of the bright and medium light groups would enhance the statistical reliability of the differences pointed out, thus bringing the groups in closer correspondence to the larger ones studied by Weiss (10).

THE DARK GROUP

In considering differences in activity between the light groups on the one hand and the dark group on the other, three facts should be kept in mind. First, the dark group is small, consisting of but six infants, in the case of each of whom only from four to twelve minutes were used for experiment. These infants were studied at a later period than either of the light groups. Further, they were studied following the bright light period, which has been shown to be rather more inhibitory than the medium light period. Lastly, the factor of adaption to dark after bright light is a complication of unknown importance. In this group there is more peristalsis, less gastric hyperactivity, and less bodily activity than in the medium light group, and less gastric hyperactivity and more peristalsis than in the bright light group. Bodily activity in both dark and bright light seems to be about the same.

These findings, tenuous as they are since based on such a small sampling of dark material, show definitely that infants who have been under a bright light, and quieted thereby, do not become increasingly active when the light is removed. Indeed, immediate responses to the removal of light, in the form of stabilimeter oscillation, occurred in but one of the six cases. We have shown earlier that the gastric balloon appears to have an inhibiting effect on bodily activity. It is possible that this factor plus the bright light may induce an inhibition which is sufficiently great to preclude the normal facilitatory effect of darkness which Weiss (10) demonstrated in a larger group of infants.

A further investigation of the relationship between bodily activity of infants under bright light and dark is shown in the tabulation following. Here are presented the activity in the eight to twelve minutes preceding dark, in the four to twelve minutes of dark, and in one minute of bright light following dark, for each of the six infants studied.

	BRIGHT LIGHT	DARK		BRIGHT LIGHT
INFANT	(8+ MINUTES)	FIRST FOUR MINUTES	REMAINING TIME (4+ MINUTES)	(1 MINUTE)
1	2.3	0.8	...	0.0
2	0.0	0.0	0.0	0.0
3	1.1	0.4	1.3	1.7
4	0.0	0.0	...	0.0
5	0.0	0.0	0.0	3.8
6	5.2	16.7	10.4	13.8
Means	1.4	3.0	2.9	3.2

It will be seen from the above that three infants inactive under the bright light showed no change when the light was removed; two infants slightly active (1 and 3) were even less active under dark; one infant, the most active of the group under bright light, was more active under dark. The increment in activity in the case of this infant was sufficient to raise the average of the group, so that the six averaged show an increase in activity as the result of removal of the bright light. However, as a whole the group is not more active in the dark, and thus does not show the tendency demonstrated by Weiss (10) for dark to induce greater activity . The number of cases is too few, however, to draw any conclusions. It is also possible that only active infants show the inhibitory effect of light. We notice with respect to the minute of light following darkness that in only one case is there

a decrease in activity. In two cases there is no change; activity remains at zero. In the remaining three cases there is an increase in activity over that of the preceding period of dark. These data tend to bear out the preceding findings, suggesting that these infants, although they are inhibited in bodily activity under long-continued bright light stimulation, are not thus inhibited immediately after a period of dark, and correspondingly are not greatly stimulated to activity immediately when bright light is removed and they are left in darkness.

Rank difference correlations for each group between factors of gastric and bodily activity were obtained as follows:

FACTORS	BRIGHT LIGHT	MEDIUM LIGHT	DARK
Bodily activity and per cent peristalsis	−.64±.12	+.08±.16	−.84±.08
Bodily activity and per cent gastric hyperactivity	+.12±.19	+.74±.11	+.95±.03
Per cent sleep and per cent peristalsis	+.49±.15	−.01±.17	.....
Per cent sleep and per cent gastric hyperactivity	−.60±.13	−.64±.12	.....
Bodily activity and per cent sleep	−.46±.15	−.79±.07	.....

Thus, bodily activity and sleep appear to vary inversely; peristalsis seems somewhat related to sleep, though only in the bright light group, where both are most frequent. The gastric hyperactivity associated with breathing appears somewhat to vary indirectly with the amount of sleep, and of course quite directly with bodily activity.

CONCLUSIONS

From this section of the study the following conclusions may be drawn:

1. Newborn infants under long-continued light stimulation of 22.0 foot candles were suggestively less active bodily than infants under 2.5 foot candles.

2. Infants under the more intense light cried less and slept more than those under the moderate light.

3. Infants under the more intense light demonstrated slightly more gastric peristalsis and gastric activity associated with breathing changes than those under the moderate light.

4. A few infants in dark after bright light, perhaps because of the quiescence engendered by the bright light, remained less active than infants under moderate light. Gastric peristalsis was more frequent in this group. This may be due to the fact that they were studied at a period later after feeding than either of the other groups.

5. Although there appears to be a relationship between gastric activity and bodily motility, and each appears to be similarly affected by a third factor—in this case light stimulation—,gastric activity may not be regarded as the excitant to bodily activity.

It is likely that in hunger gastric activity is a specific reaction and bodily activity a general reaction to the general nutritional state of the organism as expressed, perhaps, by constituents of the blood.

REFERENCES

1. Carlson, A. J., and Ginsburg, H.: Contributions to the physiology of the stomach: XXIV. The tonus and hunger contractions of the stomach of the new-born. *Amer. J. Physiol.*, 1915, 38, 29-32.
2. Irwin, Orvis C.: The amount and nature of activities of newborn infants under constant external stimulating conditions during the first ten days of life. *Genet. Psychol. Monog.*, 1930, 8, 1-92.
3. Irwin, Orvis C.: The distribution of the amount of motility in young infants between two nursing periods. *J. Comp. Psychol.*, 1932, 14, 429-445.
4. Patterson, Thomas L.: Comparative physiology of the gastric hunger mechanism. *Annals N. Y. Acad. Sci.*, 1933, 34, 55-284.
5. Peiper, Albrecht, and Isbert, Heimo: Bewegungen des Magendarmkanals im Säuglingsalter. 1. Der Magen. *Jahrb. f. Kinderh.*, 1928, 119, 291-299.
6. Richards, T. W.: The importance of hunger in the bodily activity of infants. (In press.)
7. Richards, T. W.: The relationship between bodily and gastric activity of newborn infants. I. Correlation and influence of time since feeding. Human Biol., 1936, 8.
8. Taylor, Rood: Hunger in the infant. *Amer. J. Dis. Child.*, 1917, 14, 233-257.
9. Wada, Tomi: An experimental study of hunger in its relation to activity. *Arch. Psychol.*, 1922, 8, No. 57, 1-65.
10. Weiss, LaBerta A.: Differential variations in the amount of activity of newborn infants under continuous light and sound stimulation. [In] Irwin, Orvis C., Weiss, LaBerta A., and Stubbs, Esther M.: Studies in Infant Behavior I. *Univ. Iowa Stud., Stud. in Child Welfare*, 1934, 9, No. 4, Pp. 175. (p. 9-74)

THE METABOLISM OF ALCOHOL IN MAN AT HIGH ALTITUDES[1]

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THESE experiments are concerned with comparing the effects of alcohol at high altitude with those at sea level. Variations of the concentration of alcohol in the blood at different altitudes, after the ingestion of a given quantity, may, when considered in connection with the O_2 and CO_2 tensions, the pH and lactic acid, throw further light on the metabolism of alcohol.

Himwich (7) has reviewed the evidence relative to the elimination of alcohol from the body and to the variables which influence the rate of oxidation. Only a small per cent is eliminated through the lungs, kidneys and skin. Starling (17) estimates that when small amounts are taken approximately 2 per cent is so excreted, never more than 10 per cent. For the most part alcohol disappears from the blood after absorption by oxidation in the tissues and supplies a limited amount of energy, but according to Himwich (7) alcohol is apparently oxidized at the same rate whatever the concentration. Durig (6) found the use of alcohol as a source of muscular energy physiologically unsound in mountain climbing at high altitudes. Carpenter (4, 5) believes that the disappearance of alcohol is accounted

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for in terms of heat and not in energy for bodily use. In exercise experiments he found that the amount of work had no significant effect on the rate of oxidation as determined by the respiratory exchange and the amount of alcohol in the expired air, urine and blood. Voltz and Baudrexel (18), however, reported that the rate of alcohol excretion is increased by exercise, which they attribute in part to the increased respiratory exchange during exercise.

After Henderson and Haggard demonstrated that carbon dioxide caused a more rapid de-etherization after narcosis, Hunter and Mudd (10) reported that patients in alcoholic coma were improved, in some cases to the state of mental clarity, following the inhalation of 7-10 per cent carbon dioxide for one half hour. They attributed this effect to the more rapid elimination of the alcohol associated with the increased pulmonary ventilation.

Barcroft and Haldane have mentioned the similarity of symptoms in oxygen want and alcoholic intoxication. McFarland (12) has discussed this relationship in reporting the psychological reactions associated with anoxemia. Palthe (14) was so impressed by these similarities that he attempted to relieve the effects of alcohol by the inhalation of increased percentages of oxygen. The loss of control of postural reflexes in rabbits, due to large doses of alcohol, was improved by inhaling pure oxygen. Delirium tremens patients were benefited by the administration of oxygen (with or without 5 per cent CO_2) and normal subjects improved in psychological tests. Palthe attributed the effect of the oxygen in alcoholics to its counteracting the reduction of the metabolism of the tissue cells produced by alcohol, rather than to a lowering concentration of blood alcohol since the alcoholic symptoms reappeared if the oxygen mask was removed too soon. If alcohol impairs oxidation in the tissues, Peters and Van Slyke (15) may be justified in classifying alcohol with other narcotics as producing a form of histotoxic anoxemia.

Himwich (7) has shown that there is an increase in lactic acid following the ingestion of alcohol. Recently McFarland and Barach (13) have reported that the concentrations of alcohol and of lactic acid in the blood were lowered by breathing gas mixtures of 50 per cent oxygen and 2 per cent carbon dioxide and that there was a significant improvement in reacting to psychological tests. Hill (9) states that if oxygen is inhaled during severe exertion there is a greater saturation of coronary blood and consequently greater cardiac activity and increased efficiency. In an inquiry as to whether alcohol caused tissue anoxemia Barach (1) tested the response of human subjects to a standard exercise in air and in high percentages of oxygen, with and without alcohol. He found that breathing 50 per cent O_2 produced a greater percentage decline in respiration rate and ventilation in subjects who had ingested alcohol than in those who had not.

It is frequently remarked among the inhabitants of high altitudes that alcohol has a greater effect there than at sea level. This is a common observation of well-informed residents of the mining camps in the Andes. Dr. H. L. Crane, the chief surgeon of the Cerro de Pasco Copper Company in Peru, for example, believes that one's tolerance for alcohol is decreased above 12,000 ft. and especially that "hangover" effects from the ingestion of alcohol are greater on the following day. In high altitude flying pilots have frequently reported the greater effect of small amounts of alcohol than at sea level. These subjective reports are of limited

value, however, unless substantiated by experimental evidence obtained by following the course of alcohol in the blood in the same persons at sea level and at high altitudes.

Biehler (2) followed the course of alcohol in the blood of rabbits at sea level, 1,500 meters and at 2,500 meters after the administration of doses varying from 0.9 to 3 cc. of absolute alcohol per kilo of body weight. He found that for a given dosage the concentration of alcohol in the blood reached its maximum more slowly and attains a maximum of lower value as the altitude is increased. Biehler ascribes this effect to the increased breathing occurring at high altitudes and actually observed that the amount of alcohol escaping in the breath increased from 3 to 10 per cent when the altitude was changed from sea level to 2,500 meters.

On the other hand, Bornstein and Loewy (3) have reported experiments on blood alcohol in human subjects in which they found that the concentration rose more rapidly and to a higher level at high altitudes than at sea level. They noticed, however, that after the maximum concentration was reached, the loss of alcohol from the blood proceeded at the same rate at high or low altitudes. The curves were strikingly similar for all of the three subjects tested. The doses consisted of 25-30 grams of absolute alcohol diluted to a total volume of 100 cc. They found that the volume as well as the frequency of respiration was but little affected by the alcohol either at sea level or at high altitudes. The R. Q., however, was regularly lower in the mountains than in the lowland and after the consumption of alcohol it fell in both, but fell more in the mountains. Under none of the conditions did alcohol exert any specific dynamic action, except when sugar was given together with the alcohol.

Bornstein and Loewy attribute the fact that their findings were contrary to those of Biehler to the differences between men and rabbits in the rate of absorption of alcohol from the stomach and intestines. All of their experiments were carried out on an empty stomach, while in the case of rabbits the stomach may not be empty even after a day of fasting. Loewy later published a resumé of this work together with a short discussion of the effects of ether, chloroform, ethyl bromide, morphine and strichnine at high altitudes (11).

Reichel (15) studied the effects of alcohol on reaction times in human subjects in high altitudes as compared to sea level. He observed that the alcohol had a greater effect in the mountains, especially during the first hour.

THE EXPERIMENTAL PROCEDURE

In these experiments the two subjects, W. H. F. and R. McF., were well acclimatized to high altitudes following a sojourn of over a month above 13,000 ft. The samples of blood were taken on July 8th at 'Quilcha, barometric pressure 401; altitude 17,500 ft. (5,340 meters), just four days after a stay of three days and two nights at Punta, barometric pressure 356; altitude 20,140 ft. (6,140 meters). Both subjects felt quite normal and were not suffering from the effects of mountain sickness.

The alcohol was taken under basal conditions in amounts according to body weight. W. H. F. took 170 cc. of a fluid consisting of 100 cc. of orange juice and 70 cc. or 95 per cent ethyl alcohol. R. McF. took 230 cc. of a fluid consisting of 130 cc. of orange juice and 100 cc. of 95 per cent ethyl alcohol. These amounts were approximately equal to 0.9 gms. of absolute alcohol per kilo of body weight. Exactly similar

TABLE 1

Blood Alcohol Determinations

Grams of alcohol per 100 cc. of blood at various intervals following the ingestion of alcohol as indicated, at sea level, and at 'Quilcha: barometric pressure 401, feet 17,500, meters 5,340; Oroya: barometric pressure 490, feet 12,200, meters 3,700.

	SEA LEVEL	'QUILCHA	SEA LEVEL	OROYA
R. McF.	Total volume of 230 cc. containing 100 cc. ethyl alcohol	Total volume of 230 cc. containing 100 cc. ethyl alcohol	Total volume of 230 cc. containing 100 cc. ethyl alcohol	Total volume of 230 cc. containing 100 cc. ethyl alcohol
Before	...	...	.015	.013
1/2 hour	.087	.121	.078	.117
1 hour	.120	.141	.120	.116
2 hours	.104	.161	.107	.169
3 hours	...	...	.102	.159
12 hours	...	...	.031	.088
W. H. F.	Total volume of 170 cc. containing 70 cc. ethyl alcohol	Total volume of 170 cc. containing 70 cc. ethyl alcohol		
1/2 hour	.061	.093		
1 hour	.081	.121		
2 hours	.074	.116		

R. McF. Weight 82 kg. Dose of alcohol 1.0 gm. per kilo. Arterial O_2 saturation at 'Quilcha without alcohol 81.6, pH 7.44, resting lactic acid 8.7

W. H. F. Weight 68 kg. Dose of alcohol 0.8 gm. per kilo. Arterial O_2 saturation at 'Quilcha without alcohol 79.2, pH 7.43, resting lactic acid 9.2

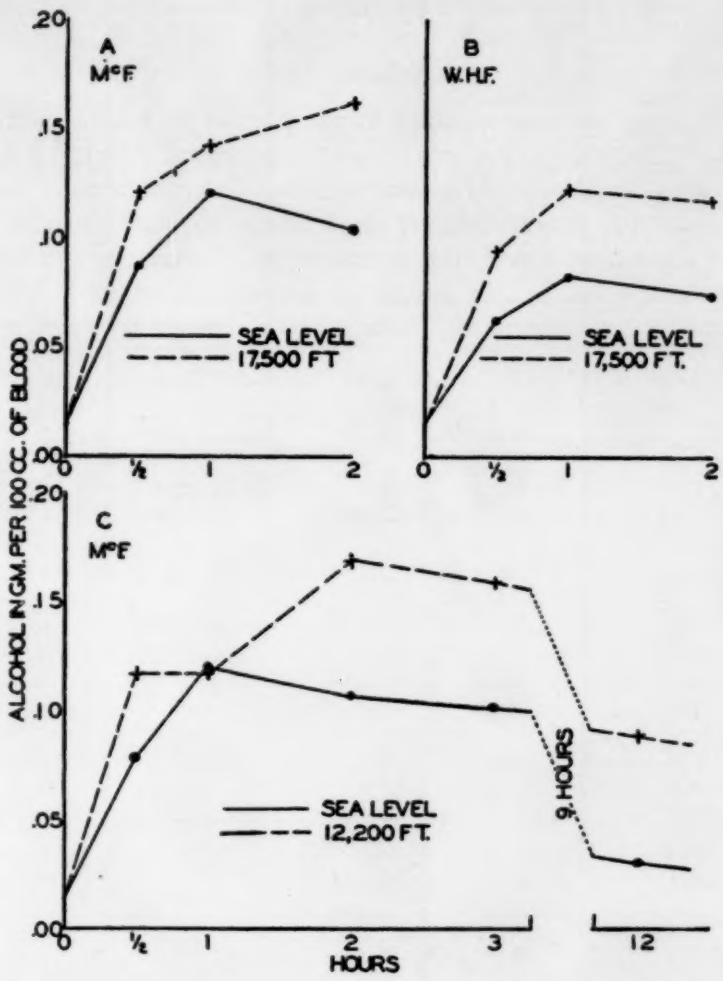

FIGURE 1. GRAMS OF ALCOHOL PER 100 CC. OF BLOOD FOLLOWING INGESTION OF ALCOHOL. *A. Subject McF.* sea level and 'Quilcha Barometric Pressure 401. 17,500 ft. (5,340 meters) altitude; 1.0 gram of alcohol per kilo body weight—230 cc. of fluid containing 100 cc. ethyl alcohol.

B. Subject W. H. F. sea level and 'Quilcha; 0.8 grams per kilo body weight—170 cc. of fluid containing 70 cc. of ethyl alcohol.

C. Subject McF. sea level and Oroya. Barometric pressure 490; 12,200 ft. (3,700 meters) altitude. Same drink as *A* above.

TABLE 2

Audiometer Test

The auditory threshold obtained by the Method of Limits on a 2A Western Electric Audiometer for eight frequencies before and a half-hour after the ingestion of various amounts of alcohol at the altitudes indicated. The figures represent the intensities expressed in sensation units; one sensation unit being equivalent to one decibel. The audiometer is calibrated so that zero on the intensity control dial represents the average adult threshold. Positive values indicate decreased sensitivity.

	RIGHT EAR								LEFT EAR							
	64	128	256	512	1024	2048	4096	8192	64	128	256	512	1024	2048	4096	8192
R. McF.																
Sea level— no alcohol..	0	−5	0	0	0	0	0	0	−5	0	0	0	0	0	5	5
Sea level— alcohol....	−0	0	5	5	5	5	10	10	0	0	5	5	5	10	5	10
12,000 ft.— no alcohol..	0	0	5	5	0	0	5	5	0	0	5	0	5	0	5	5
12,000 ft.— alcohol....	0	5	15	15	10	10	20	10	0	0	10	10	10	10	25	15
17,500 ft.— no alcohol..	0	0	0	0	5	5	10	10	0	0	5	0	5	5	10	10
17,500 ft.— alcohol....	5	5	10	10	10	15	25	20	5	5	5	10	10	20	20	25
W. H. F.																
Sea level— no alcohol..	5	0	0	0	0	5	5	0	−5	−5	−5	0	5	5	0	0
17,500 ft.— no alcohol..	−5	5	0	0	0	10	5	10	0	5	5	5	5	10	10	15
17,500 ft.— alcohol....	5	5	5	10	10	10	15	15	5	5	0	10	10	10	20	20

amounts were taken at sea level under basal conditions. The samples of venous blood (20 cc.) were taken one-half hour, one hour and two hours following the ingestion of the alcohol. The samples of blood were preserved, brought back to sea level, and Dr. H. Goldstein kindly made the alcohol determinations, all at the same time, using the method devised by Gettler (8). Duplicates were run in each case. The error of the method is 3-5 per cent.

The experiment was repeated on R. McF. a month later at Oroya, Peru barometric pressure 490; 12,200 ft. (3,700 meters). A drink consisting of a total volume of 230 cc. with 100 cc. of 95 per cent alcohol was ingested at 7 P. M., over six hours after the ingestion of food. Samples of venous blood were taken one-half, one, two, three and twelve hours later. In repeating the experiment at sea level all of these conditions were duplicated. The results are shown in Table 1 and Figure 1.

Following the first sample of blood, i.e. at the end of the half-hour, each subject was tested for auditory acuity with a 2A Western

TABLE 3

McDougall Dotting Test

Average number of contacts made on a rotating disc with a stylus during a three-minute period before, and three-quarters of an hour after, the ingestion of various amounts of alcohol at the altitudes indicated

R. MCF.	NO ALCOHOL		AFTER 1.0 GM. ALCOHOL PER KILO.	
	Mean	S.D.	Mean	S.D.
Sea level	254	4.3	204	6.6
Oroya, 12,000 ft.	234	7.2	192	8.9
'Quilcha, 17,500 ft.....	223	10.3	190	12.4
W. H. F.	**NO ALCOHOL**		**AFTER 0.8 GM. ALCOHOL PER KILO.**	
	Mean	S.D.	Mean	S.D.
Sea level	241	2.4	...	...
'Quilcha, 17,500 ft.....	222	5.4	194	9.2

Electric Audiometer. The auditory thresholds were obtained by the Method of Limits for eight different frequencies for both ears. The results are shown in Table 2. The sea level determinations were made under similar experimental conditions before and one-half hour after the ingestion of the alcohol.

At the end of the audiometer test, i.e. about 45 minutes after the ingestion of the alcohol, each subject was given the McDougall Dotting test which measures quickness and accuracy of coordination. The test involves making contacts through holes in a revolving disc with a stylus. The contacts are automatically recorded on an electric counter. At the beginning of the test the contacts are made easily, but as the line of holes goes farther out on the disc toward the outer circumference the holes pass the aperture with increasing speed, and sooner or later, depending on one's neuro-muscular control, one begins to miss the contacts. The test takes three minutes. A perfect score is 360. The means in Table 3 are based on five trials. The means obtained at sea level and at high altitude should be compared with those obtained before and after the ingestion of the alcohol under similar conditions.

THE RESULTS

Blood Alcohol

Upon examination of the blood alcohol determinations as shown in Table 1 and Figure 1 it is clear that in all three cases the concentration of alcohol in the blood rose more rapidly and reached a higher level during the first half hour in high altitude than at sea level. Our findings are in general agreement with those of Bornstein and Loewy discussed above. Once the highest concentration was reached, the rate of oxidation in gms. per hour appeared to be about the same at high altitudes as at sea level, but, due to the higher absolute values, the percentage oxidized in a given time was less at the higher altitudes. In the case of R. McF. both at 'Quilcha, 17,500 ft. and at Oroya, 12,200 ft., the maximum concentration of alcohol in the blood was reached at the end of two hours, while at sea level it was in the neighborhood of one hour.

For the subject R. McF. at Oroya, 12,200 ft. and at sea level, blood alcohol determinations were made twelve hours after the alcoholic drink, i.e. the next morning. As shown in Table 1 there was .088 gms. of

alcohol per 100 cc. of blood at high altitude and only .031 at sea level. The differences in subjective feeling also were marked. At Oroya the "hang-over", the dull headache, the tired yet restless apathy, the deep conviction that "it wasn't worth it", and general physical and psychological depression, was much more marked than at sea level.

Pulse Rate

The pulse rate was followed in McF. at sea level, at Oroya, and at 'Quilcha following the ingestion of the alcohol. For the average subject at sea level there is an initial increase followed by a retarded pulse after small amounts of alcohol. The figures below indicate that the change in the pulse rate following the ingestion of alcohol was not significantly affected by altitude.

R. McF.

	BEFORE	1/2 HOUR	1 HOUR	2 HOURS	3 HOURS	12 HOURS
Sea level	64	72	70	66	64	66
Oroya	66	74	70	65	66	68
'Quilcha	68	76	74	70	68	..

Audiometer Test

The auditory thresholds obtained by the Method of Limits with a 2A Western Electric audiometer under the various conditions indicated in Table 2 show that the impairment due to the alcohol was greater at high altitudes than at sea level. In the case of R. McF. the alcoholic drink had a slight impairing effect at sea level especially for the higher frequencies, and produced a greater impairment at high altitudes. The impairment at sea level due to alcohol was strikingly similar to the per cent loss due to the high altitude alone at 17,500 ft. The test was taken about 30-45 minutes following the ingestion of the alcoholic drink when the concentration was still rising.

McDougall Dotting Test

In this response the degree of impairment due to the alcohol in the case of R. McF. was 20 per cent at sea level, 18 per cent at Oroya and 15 per cent at 'Quilcha (see Table 3). There was a significant increase in the variablity of reactions as shown in the larger standard deviations at high altitude with or without alcohol. The tendency of the subject to counteract temporarily the impairing effect of the alcohol by exerting greater effort is shown in the increased variability.

In the case of W. H. F. the altitude had an impairing effect of approximately 8 per cent in the high altitude, with an increase in the standard deviation of approximately 42 per cent.

Both of the psychological tests were given when the concentration of alcohol in the blood was still rising. The degree of impairment might have been increased if the tests had been given later, since Gettler (8) has shown that the concentration of alcohol in the spinal fluid, and in the brain, is greatest following the highest degree of concentration in the blood.

Summary

Two subjects R. McF. and W. H. F. were given alcohol under comparable conditions of fasting, time of day, etc., at sea level and at high altitudes. The amounts of alcohol ingested were 1.0 and 0.8 gm. per kilo of body weight for R. McF. and W. H. F. respectively. R. McF. ingested a total volume of 230 cc. at sea level with 100 cc. of ethyl alcohol, at 'Quilcha, 17,500 ft., and at Oroya, 12,200 ft. W. H. F. ingested a total volume of 170 cc. with 70 cc. of ethyl alcohol at sea level and at 'Quilcha 17,500 ft. Samples of venous blood were taken from both subjects at one-half, one and two hours after the ingestion of the alcohol at 'Quilcha, and one-half, one, two, three and twelve hours from R. McF. at Oroya, 12,200 ft. Psychological tests for auditory acuity (2A Western Electric audiometer), and neuro-muscular control (McDougall Dotting Test) were given at sea level and at high altitude at definite intervals before and after the alcohol. The pulse rate was followed in the case of R. McF. at sea level and at high altitude.

CONCLUSIONS

1. The concentration of alcohol in the blood rose more rapidly and reached a higher level at high altitudes than at sea level.

2. Our observations suggest that once the highest concentration has been reached the rate of oxidation in grams per hour is relatively independent of the altitude, but due to the higher concentrations resulting from the ingestion of the same amount, the percentage oxidized in a given time is less at high altitudes, and the amount remaining in the blood after 12 hours considerably larger.

3. In one subject at high altitudes the highest values were obtained two hours after taking the alcohol, but at sea level one hour after. The other subject gave his highest values after one hour, both at sea level and on the mountain.

4. The degree of impairment in auditory acuity was greater at high altitudes than at sea level after taking the alcohol. In the test for neuro-muscular control there was a great increase in the variability of response but the average differences following the alcohol in the mountains compared with sea level were insignificant.

5. There was no significant difference in the behavior of the pulse rate at sea level and at high altitudes following the ingestion of alcohol.

BIBLIOGRAPHY

1. Barach, A. L. The action of oxygen in counteracting alcoholic intoxication. *Am. J. Physiol.*, 1934, 107; 610-15.
2. Biehler, W. Blutkonzentration und Ausscheidung des Alkohols im Hochgebirge. *Archiv. f. Exper. Pathol. und Pharm.*, 1925, 107; 20-42.
3. Bornstein, A. and Loewy, A. Über den Alkoholumsatz beim Menschen im Höhenklima. *Biochem. Zeit.*, 1931, 230; 51-67.
4. Carpenter, T. M., Lee, R. C. and Burdett, M. The effect of muscular exercise on the disappearance of ethyl alcohol in man. *Proc. Am. Physiol. Society*, 45th Annual Meeting, *Cincinnati, Ohio*, 1933.
5. Carpenter, T. M. The effect of muscular exercise on the metabolism of ethyl alcohol. *J. Nutrition*, 1933, 6; 205-225.
6. Durig, A. Beiträge zur Physiologie des Menschen im Hochgebirge. 3. Mitteilung. Über die Einwirkung von Alkohol auf die Steigarbeit. *Pflügers Arch. f. d. ges. Physiol.*, 1906, 113; 341-399.
7. Himwich, H. E. in Chap. I, of Emerson, H. Alcohol and Man. *New York*, Macmillan Company, 1932.
8. Gettler, A. O. and Freireich, A. W. Determination of alcohol intoxication during life by spinal fluid analysis. *J. Biol. Chem.*, 1931, 92; 199-209.
9. Hill, A. V. Muscular Activity. *Baltimore*, Williams and Wilkins Co., 1926, pp. 87-111.
10. Hunter, F. T. and Mudd, S. G. Carbon dioxide treatment in acute alcoholic intoxication. *Boston Medical and Surgical Journal*, 1924, 190; 971-974.
11. Loewy, A. *Physiologie des Höhenklimas*, Chap. 17, *Berlin*, Julius Springer, 1932.
12. McFarland, R. A. The psychological effects of oxygen deprivation (anoxemia) on human behavior. *Archives of Psychol.*, 1932, 145; 1-135.

13. McFarland, R. A. and Barach, A. L. The relationship between alcoholic intoxication and anoxemia. *Am. J. Med. Sciences,* 1936, 192: 186-198.
14. Palthe, P. M. Van W. Über Alkoholvergiftung. *D. Z. f. Nervenheilk.* 1926, 92, 79.
15. Peters, J. P. and Van Slyke, D. D. Quantitative Clinical Chemistry, *Baltimore,* Williams and Wilkins Co., 1931.
16. Reichel, H. Denkschr. d. Math. Naturwiss. VII. Über die psychische Alkoholwirkung in grosser Höhe. *Klasse d. Wiener Akademie d. Wiss.,* 1909, 98.
17. Starling, E. H. The Action of Alcohol on Man. *London,* Longmans, Green and Co., 1923.
18. Voltz, W. and Baudrexel, A. Über die vom tierischen Organismus unter verschiedenen Bedingungen ausgeschiedenen Alkoholmengen. *Pflügers Arch.,* 1911, 142: 47.

WORLD POPULATION GROWTH[1]

BY RAYMOND PEARL AND SOPHIA A. GOULD

I

IN A general introductory course in Human Biology given in this Department[2] considerable attention is devoted to the distribution, density, and growth of the population of the world. In connection with this it is our practice to revise annually our summary of the estimates, or counts, of the population of the world and its component parts. Some outgrowths of this work have already been published in connection with the discussion of topics of general interest.[3]

It should be emphasized that it is as impossible now as it has always been in the past, and will be for a long time in the future, to know exactly how many human beings are or were living on the face of the earth at any stated moment. The primary difficulty arises from the fact that the process of census counting has never included all the people or areas of the globe, and a secondary one from the fact that in different countries censuses are taken on different dates. But the situation grows steadily more encouraging in this respect. At the present time it can be said that over 70 per cent of the present population of the world is either regularly counted in recurring censuses, or has been counted at some time in the past, or at least an attempt has been made at a count. Of the wholly uncounted residue, for which there have never been any figures except estimates as a base, China constitutes by far the major portion. According to what seems to be the most reliable estimate, China's population constitutes something

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[1]From the Department of Biology of the School of Hygiene and Public Health of the Johns Hopkins University. We are indebted to Mrs. Ruth Pearl Jencks and Dr. John R. Miner for help in the preparation of the material for this paper.

[2]Cf. Pearl, R. Human biology in schools and colleges. *School and Society*, Vol. 42, pp. 111-118, 1935.

[3]Pearl, R. War and overpopulation. *Current History*, Vol. 43, pp. 589-594, 1935; Multiplying man. *Yale Review*, Vol. 25, pp. 584-602, 1936.

of the order of 21 per cent of the world total. When China takes a real census, if she ever does, the study of world population will then rest upon a basis of sufficient statistical security to justify a very substantial degree of confidence in results and inferences.

In the meantime—which may be a long one since China's political affairs internal and external are in a fermenting state—the problems presented by the growth of world population are so intriguing and intrinsically important that it would seem a graver error of judgment to wait placidly for an indefinitely postponed approach to statistical perfection than to tackle the problem with what material is now available, it being clearly understood that there is bound to be error and uncertainty, one way or the other, in any results reached. On the basis of all the evidence, however, we have come to feel that the error inherent in present-day discussions of total world population cannot be very great relatively. Personally we doubt that it is as much as 10 per cent plus or minus. It seems probably nearer 5 per cent if the truth could be known. We should not like to be dogmatic about either figure, however.

II

The plan in use in this laboratory for making annual revisions of world population figures is to assemble *separately* on work sheets the latest available data regarding population, area, and time (date of count or estimate) for each of the smallest demographic (areal) divisions of the earth for which data are available, and then combine them into larger divisions by summation, checking the figures at each stage in every way possible. The reasons for taking as units of the revisions the smallest areal division for which separate data are available are two-fold. In the first place by this procedure we come nearer to the actual base data with the attendant probability of greater accuracy. In the second place one of the principal problems in which we are interested is the geographic distribution of different degrees of population density over the earth's surface, and obviously the finer the areal subdivision of the material the better will be the situation for studying the problem.

When available library facilities do not permit going first-hand to original statistical sources, three well-established and generally reliable secondary sources have been used. These are:

(a) Aperçu de la démographie des divers pays du monde, publié par l'Office Permanent de l'Institut International de Statistique. *La Haye.* [Last volume issued in 1932. A new one is expected to appear shortly].

(b) Epidemiological Report of the Health Section of the Secretariat of the League of Nations. *Geneva.* [A quarterly that usually carries in each number a page of the latest available population data for selected countries].

(c) The Statesman's Year Book. [An extremely useful compilation, but of perhaps not quite the high standard of accuracy of the two preceding sources].

In addition to these three sources we expect in the future to use the Statistical Year-Book of the League of Nations, and the Revue de l'Institut International de Statistique. *La Haye.*

The working tables carry the following items of information in order:

1. Name of country or sub-division.
2. Area in square miles.
3. Total population at last recorded census or estimate.
4. Year to which population figure (Item 3) applies.
5. Density of population (persons per square mile).
6. Population at census or estimate preceding the last recorded.
7. Year to which population recorded as Item 5 applies.
8. Recent annual growth rate per cent (derived from the difference between Items 3 and 6, taken as percentage of Item 6, and reduced to an annual rate on basis of the difference between Items 4 and 7).

TABLE 1

*World Population**

	1934 REVISION	1935 REVISION
Area (square miles)	52,139,677	51,742,763
Total population (in millions)	2,050.4	2,073.3
Density (persons per square mile)	39.3	40.1
Mean date to which figures apply	1930.1	1931.5
*If China be excluded from both estimates the figures run as follows:		
Area excluding China (square mile).....	47,862,022	47,465,100
Population excluding China (millions).....	1561.1	1584.0
Density excluding China	32.6	33.4

From the last two revisions, made respectively in the autumns of 1934 and 1935, the results as to total world population and its density are shown in Table 1.

The following points are to be noted from Table 1.

1. The difference in area between the two revisions, amounting to just under 400,000 square miles, is due chiefly to changes with officially revised figures for the areas of French West Africa, Venezuela, Iraq, Nicaragua, Tanganyika, and Southwest Africa, coupled with corrections for inland waters (lakes, broad rivers, etc.) that we are able to make to an increasing extent with each succeeding annual revision. The corresponding area figure from the latest Statistical Year-Book of the League of Nations[4] is 132,390,000 km² (= 51,115,858 square miles). The discrepancy here is apparently accounted for by the fact that we include some areas (and peoples) that the League statisticians omit.

2. This last consideration also accounts for the fact that our figure for total world population of 2,073.3 millions is greater than the latest League of Nations figure, which is 2,057.8 millions. We have included estimates of uncounted native populations wherever stated figures seemed fairly reasonable; whereas the League statisticians frequently omit them. But obviously the two world estimates are in substantial agreement, the difference being only 0.75 per cent of the mean of the two estimates. A discrepancy of less than one per cent in two independent estimates of world population made at approximately the same time, is surely nothing to grieve over. Both estimates are probably somewhat *below* what the real population of the world was at the indicated time—about the middle of 1931—because the over-counts and over-estimates in the record probably do not balance the uncounted, unestimated, and therefore unrecorded folk who were, however, living.

3. The mean density of world population as of 1931.5 appears to have been almost exactly identical with that of continental United States at the 1930 census. This is a thought-provoking figure when really grasped—40 persons on the average for each 640 acres of the earth's land surface.

4. The *apparent* mean annual growth rate per cent of the world population between the dates 1930.1 and 1931.5 is 0.8 per cent; that is eight tenths of a person added in each year net to the living population for each hundred living at the beginning of the year.

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[4]League of Nations. Statistical Year-Book. 1934-35. *Geneva*, 1935.

It is uncertain as to how much significance is to be attached to this growth rate figure. For if we deal only with those countries (or other political subdivisions) for each of which there are available data from which a *separate* individual growth rate can be computed—134 "items" at the 1934 revision and 140 "items" at the 1935 revision, each "item" being a country or other political subdivision—the results shown in Table 2 are obtained.

TABLE 2

Recent world population growth rates for those countries only for which the necessary data are separately available

	1934 REVISION	1935 REVISION
Area (square miles)	38,095,193	38,369,596
Latest population (in thousands)	1,421,293.2	1,465,646.5
Mean date of above (latest) population	1930.42	1931.89
Earlier population (in thousands)	1,276,299.5	1,326,170.8
Mean date of above (earlier) population	1920.45	1924.06
Mean annual growth rate percent	1.17	1.34
Length of period on which above rate is computed (years)	9.97	7.83

The 134 countries included in Table 2 in the 1934 revision contained together 73.1 percent of the total land area of the earth (as set forth in Table 1) and 69.3 per cent of the total population. The corresponding figures for the 140 countries included in the 1935 revision are 74.2 per cent for area, and 70.7 per cent for population. These are substantial percentages of the total. The figures include none of the doubtful data (particularly those for China) embodied in Table 1. On these two grounds of large proportionate size of sample and relatively greater reliability of the data it is reasonably to be expected that the growth rates of Table 2 probably represent more accurately the general situation than does the 0.8 per cent derived from the figures of Table 1. It is, of course, also to be kept in mind that 0.8 per cent per annum increase represents only 1.4 years around 1930 and 1931, as against the 9.97 and 7.83 year intervals of Table 2. In general it would be expected statistically that relatively accurate data for a sample comprising about 70 per cent of the universe of discourse would be likely to give a fairly reliable picture of the real conditions in the whole universe—probably indeed a more reliable one than the

data for the whole universe in a case like this where it is known that the data for the part of the universe not included in the sample are dubious.

The fact that the growth rate figure of the 1935 revision (1.34) is slightly higher than that for the 1934 revision (1.17) naturally arouses skepticism. We expect human population growth rates generally to be steadily if slowly decreasing. But it will be well to reserve judgment on this point until the material presented in the next section of this paper has been considered.

In the meantime, by way of summary of this section, it is very tentatively suggested that the population of the world as a whole has been growing in the recent past at a rate of something of the order of one per cent per annum—perhaps a little more, perhaps a little less, but at about that figure. This would mean, if continued without change, a doubling[5] of the present world population in 69.7 years.

There is, however, no reason to suppose that a growth rate of one per cent per annum will continue unchanged for even any considerable part of 70 years. Nor does it appear, as will be shown in the next section, that the total population of the world will ever, in its present cycle of growth at least, be double what it is at the present time.

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[5]It may be useful to set down here in condensed form the equation from which may be computed the time required for a population to double its size at a given constant growth rate per annum. This is

$$T_{2P} = \frac{\log 2}{\log (1+r)} = \frac{0.3010300}{\log (1+r)} \qquad \text{(i)}$$

where T_{2P} = time in years required for population to double itself

r = constant rate of growth per annum expressed per unit (not per hundred units).

In the present case (i) becomes

$$T_{2P} = \frac{0.3010300}{\log (1+.01)} = \frac{0.3010300}{0.0043214} = 69.7 \text{ years}$$

Equation (i) is a simple derivation from the law of compound interest

$$s = p\ (1+r)^t, \text{ whence} \qquad \text{(ii)}$$

$$t = \frac{\log s - \log p}{\log (1+r)} \qquad \text{(iii)}$$

In the special case of time required to double the principal, $s = 2p$, and equation (iii) reduces to equation (i).

III

In 1924 Pearl[6] published (*loc. cit.* pp. 631-674) a logistic curve fitted to the data assembled by Knibbs[7] to indicate the growth of population of the world, from the estimate of Riccioli in 1660 up to and including that of Knibbs himself as of 1914. Regarding the curve the following was said at the time.

> The fit is obviously nothing to excite admiration. The most that can be said for it is that it strikes fairly through a flock of highly irregular points some of which are obviously poor guesses at world population (judged to be poor not because of their divergence from the curve, but from comparison with nearby estimates in point of time). The marvel is not that the fit is bad, but that it is as good as it is, considering how world population estimates have been made.

It became apparent some time ago that this world logistic badly needed revision because by 1930 world population *had already exceeded* 2026 millions, the upper asymptote of the original curve.

Consequently a new logistic has been fitted to the data assembled by Knibbs (given on p. 631 of Pearl, *loc. cit.*, and therefore not repeated here) with the following five additional estimates subsequent to 1914 added.

MEAN DATE OF ESTIMATE	POPULATION (in millions)	MADE BY
1920.58	1814.2	Pearl and Gould
1927.11	1978.3	Pearl and Gould
1930[8]	1901.38	Kuczynski[9]
1930.12	2050.4	Pearl and Gould
1931.52	2073.3	Pearl and Gould

The four estimates of Pearl and Gould were made by the method described earlier in this paper. Our 1927.1 and 1930.1 estimates differ from the Kuczynski estimate stated to be as of 1930 chiefly by reason of different attitudes towards the treatment of China's population. We prefer to take the official Chinese estimate rather than to guess pontifically ourselves.

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[6]Pearl, R. Studies in Human Biology. *Baltimore* (Williams and Wilkins), 1924. Pp. 653.

[7]Knibbs, G. H. The Mathematical Theory of Population, of its Character and Fluctuations, and of the Factors which Influence Them. *Census of Commonwealth of Australia*, Appendix A, vol. 1 *Melbourne*, 1917.

[8]Stated date.

[9]Kuczynski, R. R. *Encyc. Soc. Sci.*, Vol. 12, p. 245, 1935.

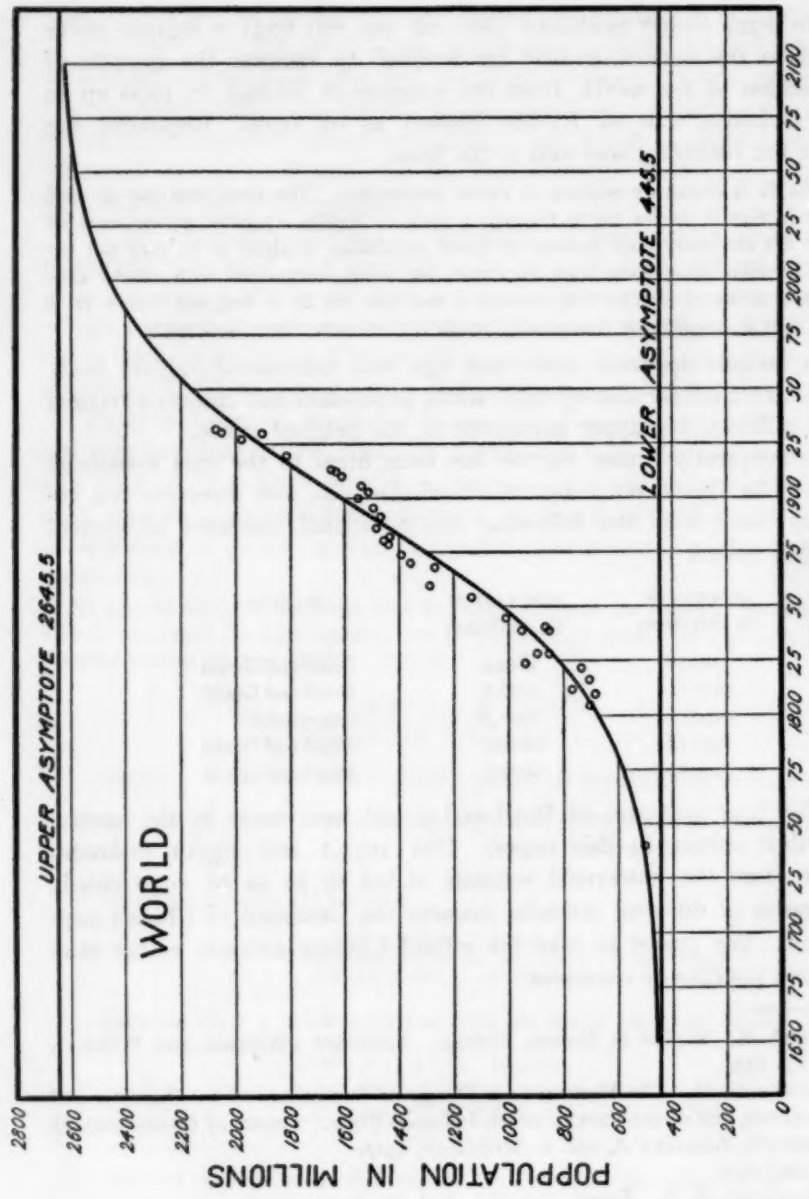

FIG. 1. THE POPULATION GROWTH OF THE WORLD FROM THE 17TH CENTURY TO 1931-2. The circles give the observations, and the smooth line the graph of the logistic equation.

In deriving the equation of the present world logistic, shown as Fig. 1, the standard procedure of fitting by the method of least squares a straight line to $\log \frac{k - y'}{y'}$ was followed. The final equation is

$$y = 445.5 + \frac{2200}{1 + 8.7349e^{-.2273x}}$$

where y is world population in millions, and x is time in 10-year intervals, from the year 1800 as origin.

Regarding the fit of the present logistic curve as a whole nothing more or very different can be said than was about the first. The nature of figures that have to be used in lieu of "observations" which even at the present date represent only about 70 per cent of complete observation precludes the possibility of ever getting anything like a really smooth fit with a four-constant curve. But taking the material for what it is, with all its inherent disabilities, a number of interesting points are presented for discussion.

In the first place the asymptotic limit of the current cycle of growth is raised above the former figure to 2645.5 millions, to be closely approached in the year 2100 A. D. We make no formal prediction that this will represent the ultimate size of the world's human population. It is only an extrapolation from the available evidence as to what the past history of world population growth has been up to the present time. No other interpretation than this should be put upon it. It is a figure that future events and trends now wholly unpredictable may alter, just as proved to be the case with our former extrapolation. If not so altered a total world population of 2645.5 millons would indicate an average population density over the whole land area of the earth of about 51 persons per square mile, instead of the present 40. This is plainly no great increase. But world population is now at a point on its logistic curve such that, unless new and unpredictable forces operate to alter its course, a slowing rate of growth will make itself increasingly manifest with the passage of time. Furthermore there is evidence[3] that the average density of world population is already approaching the point of producing uncomfortable results, under present conditions of living. But, in any case, we wish to emphasize again that we have no inside information as to whether the upper asymptote depicted in Fig. 1

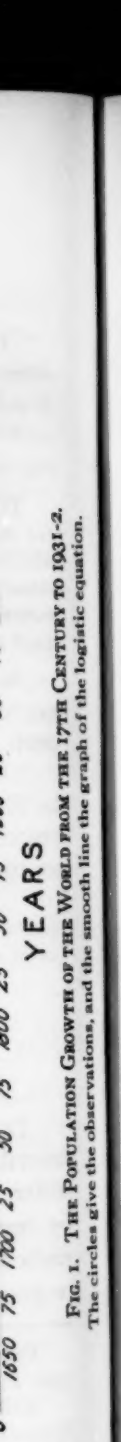

FIG. 1. THE POPULATION GROWTH OF THE WORLD FROM THE 17TH CENTURY TO 1931-2.
The circles give the observations, and the smooth line the graph of the logistic equation.

will reasonably accord with reality in the year 2100, and are not to be understood as advocating its absolute validity or significance.

Figure 1 suggests that in the period of 30 years between 1890 and 1920 the growth of world population either actually slowed below its expected trend as indicated by the fitted curve, or that the estimates of world population consistently and systematically erred in defect of

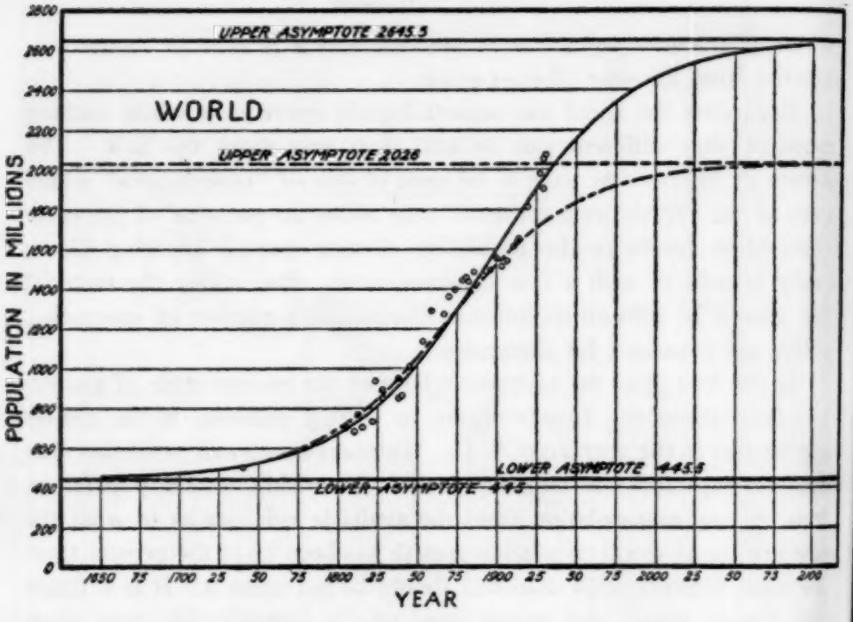

FIG. 2. SHOWING TWO LOGISTIC CURVES FITTED TO THE DATA FOR WORLD POPULATION GROWTH:
One (– – – –) fitted to the data up to 1914 only; the other (————) fitted to the data up to 1931.5.

the real facts in that period. This point is shown even more graphically in Fig. 2, in which both of our attempts at a world population logistic are plotted on the same diagram. This Fig. 2 also emphasizes the dangers inherent in extrapolating logistics, and the caution that must always be observed in generalizing or theorizing on the basis of such extrapolations.

With only the estimates at hand when our first logistic was fitted, we submit that the resulting fit was reasonable, and the extrapolated

portion of the curve what, in general, anyone would have supposed likely to happen. But actually the extrapolation was grossly in error. It can now be seen that what led us astray was the dip of the "observations" below their real long-time trend in the period of roughly 1890 to 1920. The case demonstrates with great clarity the necessity for frequent revision of human population logistics as new data become available, a point upon which one of us has always insisted from his first work with these curves.

Whether the 1890-1920 "dip" represents a real biological phenomenon, or merely bad estimating technique, is difficult to say. We incline to the view that it is probably the former, on the ground, in part, that the basis for making world population estimates was certainly better during the period in question than in earlier times and was constantly improving. More and better censuses were being taken. Furthermore it is to be noted that by 1930 the estimate had returned to, and indeed gone above, the trend line given by the curve.

IV

The present logistic cycle of world population growth got discernibly under way at about the middle of the 17th century—say 300 years ago in round figures—and started from a lower asymptotic value of about 445 millions. This figure is, of course, only an estimate, but cannot be far away from what was the actual fact. Since then it has increased to about 2,073 millions, again in round figures, as of an average date of 1931.5. In other words there has been in roughly 300 years a 4.7-fold multiplication of human beings on the face of the earth, and this present cycle of growth appears to be only about two-thirds completed. A nearly five-fold net multiplication of the population of such a relatively close-breeding species as man is, in a time period of only 300 years, is certainly a noteworthy phenomenon.

But man, as a distinct and differentiated species, had been on the earth an extremely long time prior to the 17th century. Few, if any, anthropologists nowadays question that he had become differentiated and was making flint tools of the pre-Chellean type early in the Quarternary, certainly somewhere in the first inter-glacial period. Nor is it doubted that from at least that time he has continued on the earth in an unbroken succession of generations; through the long second and third inter-glacial periods and through the glaciations that separated them. The artefacts indicative of his ever-improving culture, through

Chellean, Acheulian, Mousterian, Aurignacian, Magdalenian, and Azilian-Tardenoisian stages, make his continuous habitation certain. Geologists, anthropologists and archeologists seem, however, unable to agree as to the number of calendar years involved in the climbing of this long evolutionary ladder up which man has come. We do not propose to review all their widely varying judgments, since it is not necessary for our present purpose. Whitnall[10] synthesizing data from Penck, Osborn, Boule, and Obermaier, puts Heidelberg man and pre-Chellean culture 475,000 years back. On the other hand, Kroeber[11] tentatively allows only 100,000 years to the beginning of the lower palaeolithic.[11a] For the sake of the argument, however, and because it is so conservative as to be quite inoffensive to everybody, let us take 100,000 years as the time period to say 1630 during which man has lived on the earth. If in fact it was much longer than this, as is possible and in our opinion probable, it would only strengthen the point about to be made. Yet the world population in 1630 was only 445 million, a density of a little over 8 persons per square mile as against the present 40.

This being so at least three possible alternative inferences present themselves. The first of these is that the human population of this globe *grew* at an extremely slow rate for 100,000 years as compared with the performance of any populations now existing. On this hypothesis it is probable that the growth of world population was not steady and continuous along a smooth logistic curve, but instead was irregular,

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[10]Whitnall, H. O. The Dawn of Mankind. *Boston* (Badger) 1924. Pp. 278.

[11]Kroeber, A. L. Archaeology. *Encyc. Soc. Sci.*, Vol. 2, pp. 163-167, 1930.

[11a]While the present paper was passing through the press there came to our attention a recent paper of first-rate importance by F. E. Zeuner (*Geol. Mag.* Vol. 72, pp. 350-376, 1935) that critically synthesizes all the available data as to pleistocene chronology, and reaches conclusions that appear to be as nearly definitive as it is humanly possible to reach. It is to be hoped that archeologists and anthropologists will give them the consideration they merit. Using the Miklankowitch "radiation curve", together with other evidence from geology, paleontology and prehistoric archeology, *Homo heidelbergensis* from the Mauer sands (the oldest find in Central Europe) has a probable date on the absolute scale of about 500,000 years. Other cultures date approximately as follows: Acheulian 183,000 years; Mousterian Neanderthal man 140,000 to 105,000; Aurignacian 95,000 to 69,000; Solutrean 67,000; Magdalenian 65,000 to 18,000; Mesolithic 15,000 to 7,500; Neolithic 7,500 to 4,000, all the figures being reckoned as years before 1800 A.D. These figures, which it may again be emphasized are on the evidence far more trustworthy than any hitherto available, indicate the extreme conservatism of the estimate used in the text.

fluctuating up and down about the ever rising trend line. These fluctuations, consequent upon wars, famines, pestilences, and climatic changes, may have been relatively large at times, but absolutely well within the limit set by the 445 million asymptote finally achieved. The second possible alternative is that for a long time—thousands of years—prior to the 17th century the population of the world *stood stable* at beween roughly four and five hundred million, or oscillated in waves of relatively small amplitude about some such figure, this representing the relatively stable upper asymptotic level of a cycle of population growth consummated long before. Finally the third possible alternative is that during some period or periods in this vast span of at least 100,000 years of man's life on the earth the *world population was much higher* than 445 million, and subsequently lessened, for reasons wholly unknown, to reach that figure when reasonably reliable population history begins.

Which of these three alternatives is true? No one can say with any authority. But it seems to us that the combined evidence from paleontology, from the geographical distribution of plants and animals, from ecology and particularly plant ecology, from archaeology, from prehistory, and from history, masses such weight against the third alternative as to be practically conclusive. In short all the relevent evidence seems to indicate that there were as many (or more) human beings living on the face of the earth in 1630 as there ever had been at any prior time since man set up in business for himself. Most particularly to be counted against the third alternative is the fact that until recent times man's culture was not of the sort to make possible the existence of large populations on the earth. Hunting, pastoral, and primitive agricultural cultures are not compatible with large populations, as we know them nowadays.

The case is not quite so conclusive relative to the second alternative but still, on the balance, the evidence seems to be against it. It appears probable that if the populations had been generally stabilized for even 2000 years before the 17th century we should almost certainly have heard about it in historical writings. Instead the references and inferences about population that can be drawn from ancient history seem to indicate it as fluctuating in consequence of wars, famines, pestilences, etc., but on the whole tending always to grow, even though slowly and irregularly.

So then we are left with the first alternative, a very slow and irregular time rate of growth of world population over a very long time

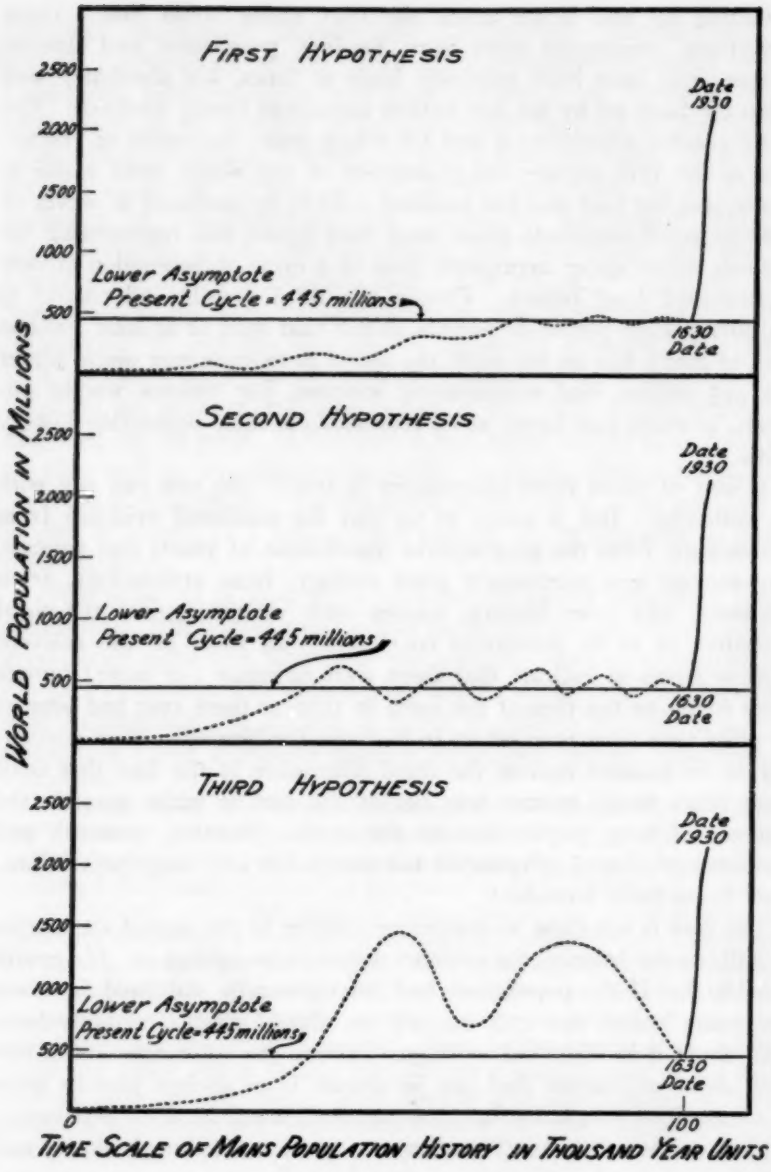


FIG. 3. DIAGRAM TO ILLUSTRATE ALTERNATIVE HYPOTHESES AS TO THE HISTORY OF THE HUMAN POPULATION OF THE EARTH.

The portions of the curve drawn in broken lines are purely hypothetical, except as to the total time scale. The portions of the curves depicted by a continuous solid line (1630-1930) represent the known facts as to world population growth, and are plotted to the same time scale as the earlier period.

prior to the Middle Ages let us say, followed by a relatively tremendous spurt of growth not yet ended.

The implications of the three alternative hypotheses will perhaps be made plainer by the diagram shown in Fig. 3.

How is this sharp spurt of population growth after 1630 to be explained? The first suggestion that comes to mind is that the primary cause behind the new cycle of logistic growth of world population that started in the 17th century was that mankind became aware about that time that its effective universe was expanding. The earth was not growing physically bigger to be sure; there were no new acres of land being really added to the planet. But many were being discovered, uncovered, and put to use, and, in general, man's *effective* universe for purposes of living certainly was expanding; and at an accelerating rate. This was being brought about by new discoveries and new ideas that made it possible for man to exploit far more effectively than he had known how to before, the natural resources for human living inherent in the earth on which he lived. It is not possible to develop this point in detail here. But one of the most important and obvious aspects of the expansive changes in man's effective universe that have appeared in the last 300 years was the ever increasing facility of communication and transportation, with its consequent broadening of the base and acceleration of the tempo of trade. Indeed it was the development of railroads that had a large part in making the gloomy prophecies of Malthus about the future of mankind at the end of the 18th century seem comically absurd soon after he made them. Another change of similar sort was the development of relatively cheap and highly effective power, associated primarily with the discovery and rapid improvement of practical steam engines. In generalized terms what expanded man's effective universe, and made possible a great spurt of population growth was scientific discovery and the application of its results, in the broadest sense including exploration as well as technology, to man's basic problem of how best to cope with and exploit his natural environment.

There is much evidence to support this view as an explanation of what is known of the whole history of human population on the earth. It would take a sizable book to review it. Only one striking feature of this mass of evidence can be mentioned briefly here. It is that, to this day, peoples who because of geographical location, climatic conditions, general stupidity, and other causes, have been unable to participate in any real sense in the consequences of an expanding effective universe, are still growing in population very slowly if at all.

V

The population of the earth is distributed with great unevenness over its land surface. This is shown in Table 3. This table is arranged in order of ascending density classes (persons per square mile). It is based upon the 906 separate political or administrative units for which separate data are available as to area and population. By "political unit" is meant either a country (as the Dominican Republic), or a state (as Arizona), or a department (as Côtes-du-Nord), or a canton (as Fribourg), or a colony, protectorate, or territory, or in a few cases a city (as Oslo) having separate administrative status equivalent legally and politically to that of a state. Each such separate political unit was put in its appropriate density class, and the areas and population summed for the class. These absolute figures were then reduced to the percentages shown in Table 3.

TABLE 3

Percentage of total land area of the earth and of total world population, by population density classes, as of average date 1930

DENSITY CLASSES (Persons per Square Mile)	PERCENTAGE OF TOTAL LAND AREA OCCUPIED	PERCENTAGE OF TOTAL POPULATION IN AREA	AVERAGE DENSITY FOR CLASS	NUMBER OF POLITICAL UNITS IN CLASS	PERCENTAGE OF TOTAL POLITICAL UNITS IN CLASS
0- 9	56.989	4.517	3.1	147	16.2
10- 39	24.433	13.731	22.1	176	19.4
40- 99	9.040	13.359	58.1	187	20.6
100- 199	4.291	15.910	145.8	187	20.6
200- 299	1.720	10.418	238.3	65	7.2
300- 399	1.745	15.650	352.8	46	5.1
400- 499	.876	9.921	445.7	25	2.8
500- 599	.176	2.310	517.7	8	0.9
600- 699	.401	6.391	626.6	15	1.7
700-1299	.316	6.610	823.5	23	2.5
1300-1899	.008	.305	1509.9	8	0.9
1900-3099	.003	.150	2063.5	5	0.6
3100 and over	.002	.728	11994.8	14	1.5
Totals and Averages	100.000	100.000	39.3	906	100.0

It should be clearly understood that the "political units" upon which Table 3 is based, are in some degree arbitrary and artificial in the sense that they are not precisely equivalent to each other geographically, anthropologically, or demographically. But for the present purpose they have this usefulness and validity: they represent 906 divisions of the land surface of the earth, for each of which the area and population are known either exactly or approximately. Therefore for each of them it is possible to compute density of population. When all *similar densities* so computed are grouped together (as in the density classes of Table 3) and their several areas added, we have large areas of the earth's surface alike in at least the respect of equal (within the class range) density of population. Thus the first density class 0-9 includes 147 "political units" whose aggregate area is over 29 million square miles. Even the highest density class (3100 and over) with only 14 "political units" has an aggregate area of over 1200 square miles.

The most striking general fact that is evident from Table 3 is the extreme skewness of the distribution of population density over the earth's surface. Taking the mean densities of the several density classes as a conservative basis for estimating the range of population density over the earth it is seen that 35.6 per cent of political units cover only 0.3 per cent of the whole range of population densities; and even 76.8 per cent of the political units cover only 1.7 per cent of the total range of densities. Even though the political units are not equivalent to each other, as has been said, nevertheless there can be no question as to the skewness of population density distribution.

The matter may be looked at in other ways that do not involve consideration of the separate political units. Well over a half (57 per cent) of the total land area of the earth is occupied by only four and a half per cent of the total population of the world. And about 81 per cent of the earth's total land area contains only 18-1/4 per cent of the world's population. Only a little over 5 per cent of the land area of the earth (densities of 200 and above) contains 52.5 per cent of its population.

Figure 4 shows graphically the broad facts of the distribution of world population over the land surface of the earth. The area of the whole square is taken as that of the land area of the globe. The lower unshaded rectangle—the "great open spaces" comprising roughly 81 per cent of the whole area—has an average density of population of only about 9 persons per square mile. The cross-hatched rectangle at the upper left corner comprises just over 13 per cent of the whole

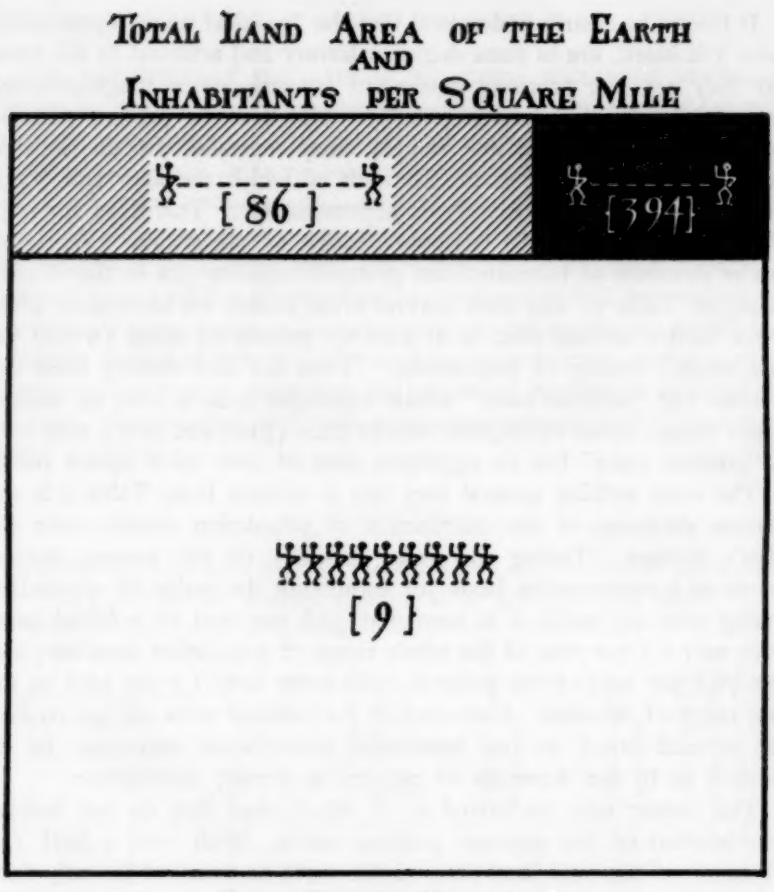


FIG. 4. For explanation see text.

land area, and contains a little over a quarter of the total world population living at the not unreasonable average density of about 86 persons per square mile. Finally, the little black rectangle in the upper right corner comprises only a little more than 5 per cent of the total land area, but contains over a half of the whole world population living at a density of 394 persons to the square mile on the average. Thus we have the picture in Fig. 4 of the biological result that human civilization had wrought by its efforts up to the year of grace 1930.

The average density of world population as a whole is 40 persons per square mile. Yet the populations on over 81 per cent of the total land area are living at densities under 40. About 14 per cent of the

population of the world—about one person in seven—is living at densities of 600 or above, that is with one acre or less per person, on an even distribution of area. As a very rough and round figure it is said that 2.5 acres are needed to support a human being.[12] Obviously this implies good land, and all of it intensively cultivated. But neglect these points for the moment, so as to put the best case possible. The data of Table 3 indicate, if we take the 2.5 acre figure at its face value and with the obviously too optimistic assumption that all land functions at that scale, that to get the means of subsistence to something over a half of the world's population today involves a significant problem of transportation and distribution. It is a common dictum that the faults and troubles connected with the "distribution" of goods are chiefly to blame for the world's woes, with the implication that if these faults could be eliminated the world's economic troubles would largely disappear. But, faults or no faults, the present geographical arrangement of world population makes it plain that *without* substantial "distribution" of the means of subsistence from the places where they are produced to the places where they are used, something over a half of all human beings could not go on living at all. Somebody *must* haul to them what they eat, what they wear, what protects them from the rigors of the physical environment, and so on. Now hauling means of subsistence is a service activity, for which somebody must be paid in the absence of a system of slavery. The aggregate economic burden so added to the business of human living on the earth, however, skillfully and intelligently it may be done, is an extremely large one. It seems bound in principle to become still greater if the tendency to unevenness of population distribution over the earth's land area—of which one aspect is, in more usual phraseology, urbanization—continues to increase. But urbanization is not the only factor involved. Another important one is the disinclination of human beings, on the whole, to move far from where they are born. For example Wattal[13] points out (p. 123) that in India, a country of relatively high population density:

"The stay-at-homeness of the people of this country is the theme of every census report. In 1901 only 9.27 per cent of the whole population were enumerated outside of the district of birth. In 1911 this proportion fell to 8.7 per cent. Even of these, two-thirds were born in a contiguous district and the move-

[12]Cf. Brown, P. E., Land and land use. *Science*, Vol. 83, pp. 337-343, 1936.

[13]Wattal, P. K. The Population Problem of India. A Census Study. *Bombay* (Bennett, Coleman and Co.) 1935. Pp. xii + 185.

ment, perhaps, from one village to another contiguous one which happened to be in another district has no connection with the pressure of economic causes. For the census of 1931 the figures are much the same. Of the total population of India enumerated by birth place, 350-1/2 million odd, less than one million were living elsewhere."

And this is in a country where Sir John Megaw[14] estimates, on the basis of a survey carried out under his direction, that (p. 61): "Under 40 per cent of the people were considered to be well nourished, while over 40 per cent were regarded as poorly nourished, and 20 per cent very badly nourished."

Viewing the animal kingdom as a whole it is evident that the ecological trend of man, as reflected in the unevenness of his population density distribution over his habitat universe, is an aberrant one. Its only even slightly plausible parallels appear to be found among the colonial Hydrozoa (where the individual zooids in the colony live at high population densities) and among the social insects. The colonial Hydrozoa do not really present a comparable situation, for there the individual zooids are bound to the colony and cannot migrate individually, generally speaking; nor are they true individuals biologically. The social insects, on the other hand furnish a closer and more real parallel. Indeed the tendency of human social organizations to approach more and more closely that of the termites has been evident for a century at least; with its increasingly rigid differentiation of occupational castes, its abrogations of individual liberty of action, its heavy and ever-growing burden of economic overhead service expense entailed in getting subsistence; all these being direct consequences of living under conditions of high population density.

There are, of course, many species of animals that during certain phases of their life histories live for relatively short periods of time under conditions of great population density and consequent unevenness of density distribution relative to their whole habitat range. Conspicuously, many forms aggregate to high population densities in restricted areas during the breeding season. Certain fish, and notably the salmon, are examples in point. But except in the breeding season the areal distribution of such forms is widespread and the population density low. But man, and certain of the social insects, when they live at high population densities *live that way all their lives*. We have found

[14]Megaw, Sir John. Public health in India; retrospect and prospect. *Lancet*, Vol. 230, pp. 61-63, 1936.

it difficult to think of other forms falling in exactly the same category in this respect. Perhaps there are some, but certainly they are neither numerous nor conspicuous.

VI

The significant points brought out in this paper may be briefly summarized as follows:

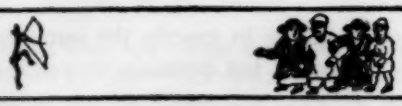
1. The method of making annual revisions of estimated world population used in this laboratory is described, and the estimates presented of 2,050.4 million and of 2,073.3 million, as of average dates 1930.1 and 1931.5 respectively.

2. The tentative conclusion is reached that the population of the world has been growing in the recent past at the rate of about one per cent per annum.

3. A logistic curve fitted to the data on world population growth leads to an upper asymptotic value for the present cycle of 2,645.5 million, rather closely approached by about 2100 A. D.

4. The prehistory and history of human population on the earth is discussed, and it is shown that since the middle of the 17th century world population has exhibited an extraordinary spurt of growth, unparalleled before that time so far as the available evidence indicates. It is suggested that this is a consequence of the expansion of man's effective universe, as a result of scientific discoveries and their application.

5. The extreme unevenness of the distribution of population densities over the earth's land surface and some of its general economic consequences are discussed. Well over a half (57 per cent) of the total land area of the earth is occupied by only four and a half per cent of the total population of the world. About 81 per cent of the earth's total land area contains only 18-1/4 per cent of the world's population. Only a little over 5 per cent of the land area of the earth contains 52.5 per cent of its population.



FERTILITY IN RELATION TO AGE AT TIME OF MARRIAGE*

BY GERARD ROLAND POMERAT

From the Department of Biology, Clark University

IN A recent analysis of a consecutive series of 107 infertile married couples which were thoroughly studied for diagnostic purposes at the Evans Memorial (Boston, Massachusetts), Pomerat (8) obtained as an outstanding characteristic of the infertile group an age correlation between husband and wife of 0.51 ± 0.05. This is about twenty points below the figures of 0.76, 0.75, 0.69, and 0.79 reported by Lutz (2), Carter (1), Schiller (10), and Outhit (5) respectively.

The present study was undertaken to investigate further the possible relation between infertility and age of husband and wife at time of marriage.

MATERIALS AND METHODS

The cases discussed here were selected from the marriage records of the city of Worcester, Massachusetts, (population around 200,000), for the years 1916 and 1917. All the couples were residents of Worcester at the time of their marriage and remained in that city for at least fifteen consecutive years thereafter. No couples were included in which the woman was over 40 years at time of marriage. Of the 4300 marriages recorded for those years, only 987 were found to meet these requirements, (23 per cent). In 191 of the cases selected (19.35 per cent) no births or stillbirths were registered. This is considerably higher than the range of 10 to 13 per cent for Massachusetts families which Meaker (3) quotes from Macomber.

*The author wishes to acknowledge his thanks to Mr. Charles M. Pomerat and to Dr. Raymond R. Willoughby, both of Clark University, for the many helpful aids and suggestions which have made this study possible.

TABLE I

Male Age at Time of Marriage

AGE GROUP	ALL COUPLES		COUPLES WITH CHILDREN		CHILDLESS COUPLES	
	FREQUENCY	% OF N	FREQUENCY	% OF N	FREQUENCY	% OF N
17-18	10	1.01	9	1.13	1	0.52
19-20	38	3.85	37	4.65	1	0.52
21-22	161	16.31	146	18.34	15	7.85
23-24	189	19.15	156	19.60	33	17.28
25-26	167	16.92	145	18.22	22	11.52
27-28	121	12.26	97	12.19	24	12.57
29-30	91	9.22	70	8.79	21	10.99
31-32	57	5.78	47	5.90	10	5.24
33-34	52	5.27	39	4.90	13	6.81
35-36	35	3.55	17	2.14	18	9.42
37-38	20	2.03	14	1.76	6	3.14
39-40	11	1.11	4	0.50	7	3.66
41-42	10	1.01	4	0.50	6	3.14
43-44	8	0.81	4	0.50	4	2.09
45-46	11	1.11	5	0.63	6	3.14
47-48	3	0.30	1	0.13	2	1.05
49-50	..	...	..	...	..	...
51-52	1	0.10	1	0.13	..	....
53-54	2	0.20	..	....	2	1.05
Totals:	987	100.	796	100.	191	100.
Mean	26.969±0.123*		26.198±0.120		30.181±0.349	
Standard Deviation	5.722±0.087		5.032±0.085		7.132±0.246	
Significance	$\frac{\text{Diff.}}{\text{P.E.(diff.)}} = 10.79$					

*P.E. used throughout this paper.

AGE AT TIME OF MARRIAGE

The mean age at marriage for all males included is 26.979 years. The males of the fertile group have a marriage age mean of 26.198, while the childless males averaged 30.181 years at marriage.

The mean age at marriage for all females is 24.987, while that of the fertile group is 23.573 years as against 28.128 for the childless group.

The couples showed a difference in age at time of marriage ranging from 0 to 25 years with a mean of 3.602 years for all couples and

TABLE 2

Female Age at Time of Marriage

AGE GROUP	ALL COUPLES		COUPLES WITH CHILDREN		CHILDLESS COUPLES	
	FREQUENCY	% OF N	FREQUENCY	% OF N	FREQUENCY	% OF N
15-16	10	1.01	10	1.26	..	....
17-18	65	6.59	65	8.17	..	....
19-20	126	12.77	119	14.95	7	3.66
21-22	194	19.66	170	21.36	24	12.57
23-24	178	18.03	151	18.97	27	14.14
25-26	137	13.88	105	13.19	32	16.75
27-28	93	9.42	76	9.55	17	8.90
29-30	56	5.67	39	4.90	17	8.90
31-32	52	5.27	33	4.15	19	9.95
33-34	30	3.04	11	1.38	19	9.95
35-36	24	2.43	9	1.13	15	7.85
37-38	17	1.72	7	0.88	10	5.24
39-40	5	0.51	1	0.13	4	2.09
Totals:	987	100.	796	100.	191	100.
Mean	24.987±0.105		23.573±0.103		28.128±0.260	
Standard Deviation	4.890±0.074		4.302±0.073		5.312±0.183	
Significance	$\frac{\text{Diff.}}{\text{P.E.(diff.)}}$		16.33			

means of 3.502 and 3.861 years for the fertile and childless groups respectively. The Evans Memorial group, on the other hand, shows an age difference of 4.538 years.

Pearson product-moment correlations were done for age of husband and wife at time of marriage. The group which includes all couples gave an r of 0.704±0.011, but there is no significant difference

TABLE 3

Age Difference In Couples at Marriage

AGE DIFFERENCE	ALL COUPLES		COUPLES WITH CHILDREN		CHILDLESS COUPLES	
	FREQUENCY	% OF N	FREQUENCY	% OF N	FREQUENCY	% OF N
0-1	299	30.29	245	30.78	54	28.27
2-3	280	28.37	218	27.39	62	32.46
4-5	201	20.36	170	21.36	31	16.23
6-7	99	10.03	80	10.05	19	9.95
8-9	49	4.96	41	5.15	8	4.19
10-11	32	3.24	25	3.14	7	3.66
12-13	10	1.01	4	0.50	6	3.14
14-15	9	0.91	8	1.01	1	0.52
16-17	4	0.41	3	0.38	1	0.52
18-19	1	0.10	1	0.13	..	....
20-21	2	0.20	1	0.13	1	0.52
22-23	..	....	..	....	..	....
24-25	1	0.10	..	....	1	0.52
Totals:	987	100.	796	100.	191	100.
Mean	3.602±0.071		3.502±0.075		3.861±0.186	
Standard Deviation	3.286±0.050		3.146±0.053		3.812±0.312	
Significance	$\frac{\text{Diff.}}{\text{P.E.(diff.)}} =$		1.79			
Marr. Age Correlation	$r = 0.704 \pm 0.011$		$r = 0.639 \pm 0.014$		$r = 0.693 \pm 0.026$	

between the value for the fertile group (0.639±0.014) and that of the childless group (0.693±0.026). The data from which these figures are taken are given in tables 1, 2, and 3.

Additional information was obtained from the Evans Memorial and the data of Pomerat were recalculated to secure comparable figures.

TABLE 4

Age at Time of Marriage—Evans Memorial Data

AGE GROUP	MALES		FEMALES	
	FREQUENCY	% OF N	FREQUENCY	% OF N
15-16	..	....	1	0.94
17-18	..	....	6	5.66
19-20	2	1.89	11	10.38
21-22	5	4.72	27	25.47
23-24	17	16.04	22	20.75
25-26	24	22.64	16	15.09
27-28	20	18.87	13	12.26
29-30	14	13.21	4	3.77
31-32	11	10.38	2	1.89
33-34	7	6.60	1	0.94
35-36	4	3.77	2	1.89
37-38	1	0.94	1	0.94
39-40	..	....	..	....
41-42	..	....	..	....
43-44	..	....	..	....
45-46	..	....	..	....
47-48	1	0.94	..	....
Totals	106	100.	106	100.
Mean	27.632±0.278		23.783±0.258	
Standard Deviation	4.248±0.197		3.984±0.175	
Diff. * / P.E.(diff.)	4.74		0.76	

*Compared to "Couples with Children" of this study.

TABLE 5

Fifteen Year Summary of Births

NUMBER IN FAMILY		0	1	2	3	4	5	6	7	8	9	10	TOTAL CHILDREN	% BIRTHS	MEAN	STANDARD DEVIATION
Males	Frequency	342	317	166	94	46	17	3	1	1	...	...				
	% of Couples	34.65	32.12	16.82	9.52	4.66	1.72	0.30	0.10	0.10	...	...	1233*	51.46	1.249±0.028	1.294±0.020
Females	Frequency	358	304	189	82	37	15	2	...	...	...	...				
	% of Couples	36.27	30.80	19.15	8.31	3.75	1.52	0.20	...	...	...	...	1163	48.54	1.178±0.026	1.219±0.019
Total	Frequency	191	192	190	144	104	83	42	27	8	4	2				
	% of Couples	19.35	19.45	19.25	14.59	10.54	8.41	4.26	2.74	0.81	0.41	0.20	2396	100.	2.428±0.044	2.023±0.031
Stillbirths		...	38	7	1	...	...	...	...	...	...	...	55	2.30		
One-Sex Twins		...	...	18	...	...	...	...	...	...	...	...	36	1.50	2.84% of Births	
Mixed Twins		...	...	16	...	...	...	...	...	...	...	...	32	1.34		

*All groupings include Stillbirths.

TABLE 6

MALE AGE AT MARRIAGE	MEAN BIRTHS PER COUPLE
17	2.000*
18	3.333
19	3.364
20	2.593
21	3.048
22	2.714
23	2.315
24	2.639
25	3.151
26	2.728
27	2.697
28	2.145
29	2.156
30	2.217
31	1.887
32	2.303
33	1.692
34	2.346
35	1.303
36	0.867
37	1.500
38	1.667
39	1.000
40	1.000
41	1.750
42	1.000
43	0.667
44	1.200
45	0.600
46	1.333
47	0.500*
48	0.000*
51	1.000*
53	0.000*

TABLE 7

FEMALE AGE AT MARRIAGE	MEAN BIRTHS PER COUPLE
15	5.250
16	3.833
17	4.167
18	3.415
19	3.209
20	3.026
21	2.683
22	2.921
23	2.656
24	2.607
25	2.056
26	2.136
27	2.674
28	1.960
29	2.167
30	1.308
31	1.800
32	1.031
33	0.267
34	1.200
35	0.786
36	0.900
37	0.555
38	0.625
39	0.200

TABLE 8

AGE DIFF. AT MARRIAGE	MEAN BIRTHS PER COUPLE
0	2.421
1	2.422
2	2.273
3	2.271
4	2.563
5	2.928
6	2.741
7	2.512
8	2.179
9	2.429
10	2.125
11	1.625
12	0.667
13	1.000
14	2.800
15	2.250
16	4.500*
17	1.000*
18	7.000*
20	0.000*
21	1.000*
24	0.000*

*Includes less than three cases each.

TABLE 9

Number of Births per Couple for Each Year of Marriage Duration

MARRIAGE YEAR	MALES			FEMALES			TOTAL		
	Number	Mean	%	Number	Mean	%	Number	Mean	%
1	258	0.261	20.92	253	0.256	21.75	511	0.518	21.33
2	117	0.119	9.65	141	0.143	12.12	258	0.261	10.77
3	127	0.129	10.30	126	0.128	10.83	253	0.256	10.56
4	115	0.117	9.33	99	0.100	8.51	214	0.217	8.93
5	87	0.088	7.06	90	0.091	7.74	177	0.179	7.39
6	80	0.081	6.49	78	0.079	6.71	158	0.160	6.59
7	90	0.091	7.30	54	0.055	4.64	144	0.146	5.91
8	65	0.066	5.27	64	0.065	5.50	129	0.131	5.38
9	65	0.066	5.27	54	0.055	4.64	119	0.121	4.97
10	58	0.059	4.70	52	0.053	4.47	110	0.111	4.59
11	58	0.059	4.70	42	0.043	3.61	100	0.101	4.17
12	40	0.041	3.24	28	0.028	2.41	68	0.069	2.84
13	27	0.027	2.19	37	0.037	3.18	64	0.065	2.67
14	29	0.029	2.35	27	0.027	2.32	56	0.057	2.34
15	17	0.017	1.38	18	0.018	1.55	35	0.035	1.46
First 5 years	704	0.713	57.10	709	0.718	60.96	1413	1.432	58.97
Second 5 years	358	0.367	29.03	302	0.306	25.97	660	0.669	27.55
Third 5 years	171	0.173	13.87	152	0.154	13.07	323	0.327	13.48
First 10 years	1062	1.076	86.13	1011	1.024	86.93	2073	2.100	86.52
Total 15 years	1233	1.249	100.0	1163	1.178	100.0	2396	2.428	100.0

TABLE 10

Duration of Marriage before First Child

YEAR	1	2	3	4	5	6	7	8
Number Cases:	485	136	69	38	17	11	10	9
% of Cases	60.93	17.09	8.67	4.77	2.14	1.38	1.26	1.13

	YEAR	9	10	11	12	13	14	15
(con't)	Number Cases:	8	2	2	2	3	3	1
	% of Cases	1.01	0.25	0.25	0.25	0.38	0.38	0.13

Mean = 2.064±0.050
Standard Deviation = 2.082±0.035

(One case in which the wife was over 40 at time of marriage is not included). The mean age of males at time of marriage for this group is 27.632 and that of the females is 23.783 years. The recalculated correlation value for age between husband and wife at marriage is 0.419±0.054, and the mean duration of marriage is 5.726 years. See Table 4.

RECORD OF FERTILITY

Table 5 gives a summary of the births which occurred in the 15 years following the marriages of the 796 fertile couples. The mean number per family is 2.428 and this includes 2.3 per cent registered stillbirths. The ratio of males to females is 51:48.

The pregnancy and birth rates were calculated according to the method described by Pearl (6). The entire group of women gave a rate of 1.4 pregnancies per 100 ovulations, while the exclusion of the childless wives brought the rate to 1.8 per ovulation which is considerably below the rate of 5.8 given by Pearl (7) for women not using contraceptives.[1]

[1]The women in this series had an average exposure to pregnancy of 4.40 years, while those in this study have an average of 13 years, approximately.

The birth rate for the entire group was 1.4 per 100 ovulations for all the women and 1.7 for the fertile group only.

Tables 6, 7, and 8 give the mean number of births for each male age at marriage, female age at marriage, and age difference at marriage respectively. Table 9 gives the number of births per couple for each year of marriage duration, and Table 10 gives the duration of marriage for the birth of the first child. Standard deviations are not included because they were found too large with respect to the means.

DISCUSSION

There does not seem to be any significant difference between the male-female marriage age correlation of the fertile and childless couples included in this study ($\frac{\text{Diff.}}{\text{PE(diff.)}} = 1.83$) .

The reliability of the difference in mean age at marriage between the fertile and childless husbands, however, is very high (10.79), while that between the wives of the same two groups is even higher (16.33).

The frequencies of age distribution shown in Tables 1 and 2 were reduced to per cents and plotted in Figures 1 and 2. It will be seen that the graphs of the male and female marriage ages of the childless couples tend to fall on the right of the fertile group and that in the higher age groups the childless partners predominate.

Chi-square tests were done on the fertile and childless age distributions for both males and females and gave χ^2 values of 99.644 and 148.539, respectively, so that the chances of obtaining these distributions by random selection are less than 1 in 1,000,000 for either case.

These findings would tend to corrborate the conclusions of Müller (4) who stated in 1931 that "Human fertility undoubtedly varies with age of the husband as well as with age of the wife at marriage and with duration of marriage".

The age of marriage distribution for Evans Memorial data is also plotted on these graphs for comparision. The female distribution seems to follow that of the fertile women of this series, but the male distribution definitely resembles that of the childless males. This dissimilarity in distribution between the males and females of the Evans Memorial data is to be expected in view of the low marriage age correlation.

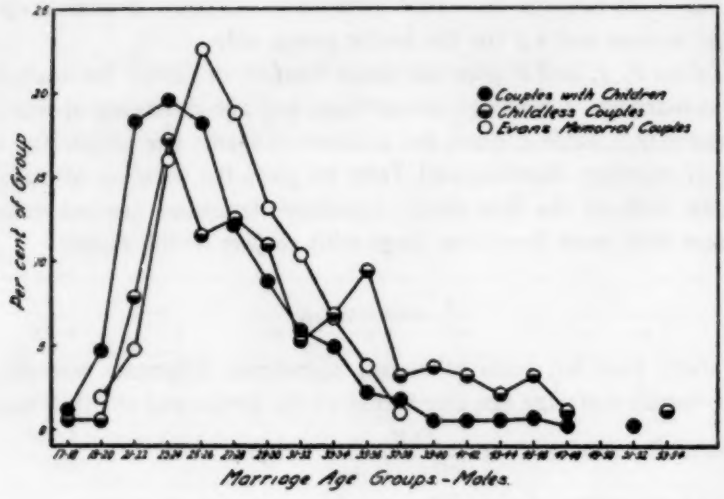


FIGURE 1

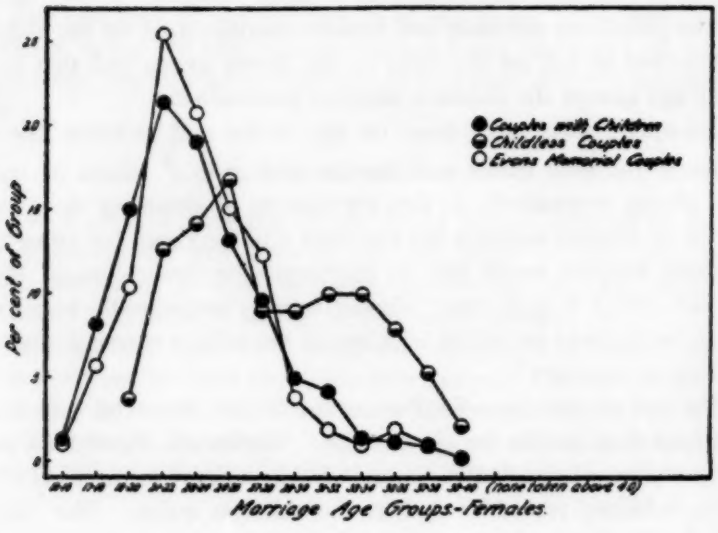


FIGURE 2

No attempt is made to explain the low fertility among the couples having children during the fifteen year period included in this study.

It is interesting that Willoughby (12), studying the size of families of professors in a small college located in this same city, found the mean number of children to be 1.40 and that Spengler (11), working with data from Providence, Rhode Island, found that the average number of children born per mother bearing children in that city was 2.97 in 1929.

SUMMARY AND CONCLUSIONS

1. In order to determine the influence of age on fertility, the birth records of 987 couples were studied for a period of 15 years.

2. 19.35 per cent of the couples in this series were infertile, which is considerably higher than is reported.

3. The mean age at time of marriage for males and females was decidedly higher in the infertile group.

4. No significant difference was found in age difference nor in age homogamy at time of marriage between the fertile and infertile groups.

5. The mean number of children per fertile family is 2.428 for the 15 year period.

6. Infertile husbands and wives have a characteristically higher mean age at marriage than the fertile couples, and the per cent in the higher age group is higher.

7. Material from another infertile group (Evans Memorial), when compared with these results, shows a similar high mean age and distribution for the males but not for the females.

8. Homogamy on the basis of age does not seem to be related to infertility, while age, particularly of the male, seems to be a definite factor in infertility.

BIBLIOGRAPHY

(1) Carter, H. D., Family resemblances in verbal and numerical abilities, *Genet. Psychol. Monog.* 12, 1-104, 1932.

(2) Lutz, F. E., Assortative mating in man, *Science*, 22, 249-250, 1905.

(3) Meaker, S. P., Human Sterility, Causation, Diagnosis and Treatment, Williams & Wilkins, *Baltimore*, 1934.

(4) Müller, J. H., Human fertility in relation to ages of husband and wife at time of marriage, and duration of marriage, *Ann. Eugenics*, 4, 238-278, 1931.

(5) OUTHIT, M. C., A study of the resemblances of parents and children in general intelligence, *Arch. Psychol.*, 149, 1933.
(6) PEARL, R., Factors in human fertility and their statistical evaluation, *Lancet*, 2, 607-611, 1933.
(7) PEARL, R., Studies on the effectiveness of contraception, HUMAN BIOL., IV, 363, 1932.
(8) POMERAT, C. M., Homogamy and infertility, HUMAN BIOL., 8, 19-24, 1936.
(9) POMERAT, C. M., Assortative marriage and infertility, *Science*, 78, 2024, 336, 1933.
(10) SCHILLER, B., A quantitative analysis of marriage selection in a small group., *Jour. Soc. Psychol.*, 3, 3, 297-319, 1932.
(11) SPENGLER, J. J., Fertility in Providence, R. I., *Am. Jour. Soc.*, 38, 377-397.
(12) WILLOUGHBY, R. R., The dying professor; study in faculty family size, *Jour. Hered.*, 21, 273, 1930.

THE TWELVE-DAY OLD BABY*

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FOR the past three years we have been engaged in an anthropometric study of the newborn infant and its parents. The object in mind in this work has largely been an enquiry into the question why the processes of labor in some cases are relatively easy and uncomplicated whereas in others—without any apparent cause—they are full of dangers and difficulties. We therefore have kept accurate records of both parents as well as of the infant and have made an attempt to classify them racially.

The following preliminary report, however, deals only with the investigation of the physical proportions of the infant. It consists of a series of 700 infants born in the Obstetrical Department of the Toronto General Hospital and measured on the twelfth day, and it was thought in itself to present sufficient interest, particularly as some important information is to be gathered on the question as to what constitutes a full-term baby and wherein it differs, if at all, from the foetus. We therefore set out to determine what the relations of the various segments of the body of the infant were to one another and to the total length, and to see if these relations were exactly comparable to those established by other workers for the later foetal period, and especially to those recorded by Scammon and Calkins (1). It should be remembered that whilst we were dealing with infants all of the same chronological age, nevertheless they varied in total length from 46 to 58 centimeters and it is within the limits of this relatively small range that all our new-born infants fall, so that the behavior of the various parts of the body within this small range is of considerable importance and worthy of an intensive study. The records were made by Dr. J. C. Goodwin, assisted by Drs. D. Irwin and D. Borsook, all of whom worked to an established technique, and the last of whom is responsible for the

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taking of the greatest number of measurements. Dr. Cates, alone, is responsible for the statistical treatment of the material.

An enquiry into the question of how far the results are affected by the fact that three workers were engaged in collecting the raw data showed that there was no appreciable difference in the precision with which each dimension was taken by each of the three observers, and in consequence an analysis of the precision of one worker only (D. Borsook) is presented.

METHOD

A special measuring board was devised and has been in constant use for over three years. It has given quite satisfactory results and a cut shown in Figure 1 is almost self-explanatory. It was found particularly valuable for midline measurements, and it consists essentially of a head piece, a sliding foot piece,—to measure total body length and crown-rump length,—and a sliding middle piece holding a moveable arm in the middle of its arch to measure the various midline distances from the crown, viz:— crown-sternal, crown-xiphisternal and crown-pubic. By using the small metal arm at the sides of the arch rather than as shown in the midline, crown-cristal, trochanteric height and knee height could readily be measured. The instrument is calibrated on both sides as a check. A cross calibrated piece provides for span. For the rest of the body measurements a sliding caliper was used for bi-deltoid, bi-trochanteric and foot length, and a spreading caliper for intercristal, interspinous and external conjugate. The upper limb was measured by tape from the tip of the middle finger to the styloid process of the radius for hand length, thence to the lateral epicondyle of the humerus for forearm length, and thence to the tip of the acromion for arm length. It was perhaps unfortunate that as a result of this method a summation of errors occurs in forearm and arm lengths which will, however, be further noted in considering these measurements. For the head a linen tape was used for circumferential measurements and the incisura anterior of each ear was used for measuring the auriculo-vertex arc. The spreading caliper was again used for the various head and face dimensions, and Todd's head spanner for determining head height. Weights were taken on a standard baby scale in pounds.

In order to determine the precision with which each dimension was measured the following procedure was adopted:— Each investigator recorded 30 measurements of a single dimension under con-

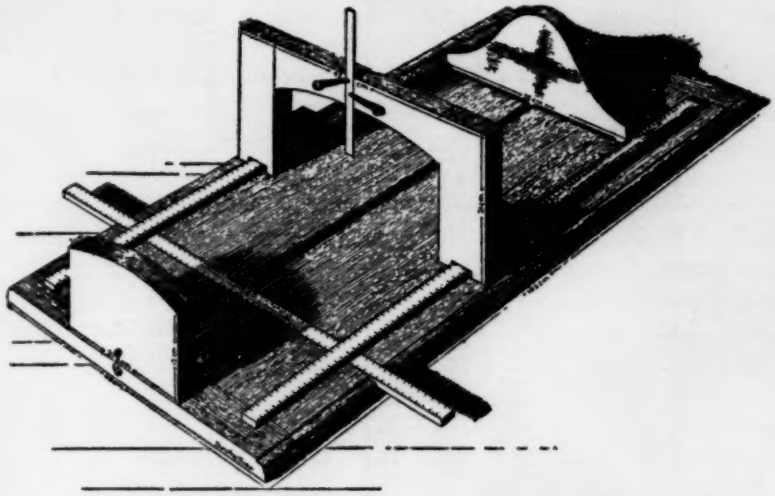

FIG. 1. ANTHROPOMETRIC MEASURING BOARD FOR INFANTS

sideration on one subject. This was done at one sitting and an independent observer read the instrument and noted the result each time. The process was repeated for each dimension, using a new subject each time, so that in all 31 subjects were used. In this way it was possible to determine how precisely the work was being done. Table 1 shows these records as made by D. Borsook. As the other two workers showed at most no greater variability it was not thought necessary to include their results. In the table are shown maximum and minimum measurements for each dimension and the mean of the 30 measurements, as well as the probable error of the mean, standard deviation and its error. If it is borne in mind that after all the standard deviation is itself a measure of variability, or the precision with which each dimension is measured, then a consideration of this standard deviation in relation to the mean will allow us to compare the precisions obtained in measuring each dimension. This has been done by use of the formula $\frac{100\sigma}{M}$, commonly referred to as the coefficient of variability, and the last column reveals that total body length was measured most precisely. It is therefore a good dimension to use, against which to plot other dimensions. There are of course other obvious advantages in using total body

TABLE 1

Record of Precision Obtained in Measuring Each Dimension

DIMENSION	MIN. CM.	MAX. CM.	MEAN CM.	EM ±	σ	E_σ	$\frac{100\sigma}{M}$
Total Body Length	53.3	54.0	53.7	.033	.221	.023	0.41
Crown-Sternal	12.4	13.0	12.65	.024	.160	.017	1.27
Crown-Xiphisternal	18.8	19.5	19.2	.030	.206	.021	1.07
Crown-Cristal	27.1	28.3	27.7	.046	.306	.033	1.10
Crown-Pubic	31.7	32.6	32.2	.033	.220	.023	0.68
Crown-Rump	35.2	35.9	35.6	.028	.188	.020	0.53
Span	47.8	49.4	48.7	.076	.510	.054	1.05
Bi-Deltoid Width	13.8	14.4	14.1	.027	.185	.019	1.31
Bi-Trochanteric Width	8.7	9.0	8.85	.015	.101	.011	1.15
External Conjugate	6.1	6.7	6.3	.023	.158	.016	2.51
Intercristal	7.6	7.9	7.7	.011	.073	.008	0.95
Interspinous	7.3	7.6	7.4	.016	.109	.011	1.47
Arm Length	8.0	8.8	8.3	.031	.204	.022	2.46
Forearm Length	6.2	7.0	6.6	.034	.229	.024	3.47
Hand Length	6.7	7.2	7.0	.021	.141	.015	2.01
Trochanteric Height	20.5	21.2	20.8	.028	.190	.020	0.91
Knee Height	9.1	9.7	9.4	.021	.138	.015	1.47
Foot Length	8.2	8.8	8.5	.026	.172	.018	2.02
Nasion-Menton	4.8	5.3	5.1	.017	.112	.012	2.20
Bi-Malar Width	7.7	8.0	7.8	.012	.080	.008	1.03
Bi-Gonial Width	5.0	5.6	5.5	.019	.124	.013	2.25
Head Length Max:	12.8	13.0	12.9	.009	.062	.006	0.48
Head Width Max:	9.9	10.0	10.0	.007	.050	.005	0.50
Head Width Min:	7.5	7.8	7.7	.010	.070	.007	0.91
Head Height	7.7	8.0	7.8	.020	.136	.014	1.74
Subocc:-Vertex-Nasion Arc	22.1	22.5	22.3	.017	.112	.012	0.50
Auriculo-Vertex Arc	21.9	22.7	22.3	.033	.222	.023	1.00
Subocc:-Frontal Circ:	33.0	33.6	33.4	.026	.171	.018	0.51
Subocc:-Frontal Diam:	11.8	12.2	11.9	.020	.132	.014	1.11
Subocc:-Bregmatic Circ:	31.8	32.6	32.2	.028	.193	.020	0.60
Subocc:-Bregmatic Diam:	10.7	11.0	10.9	.011	.073	.008	0.67

length as a standard of comparison. Crown-rump length is also a dimension which may be measured with considerable precision. In general dimensions involving bony points can be measured more precisely than those in which soft parts are involved, though there are some exceptions (external conjugate and nasion-menton) but these exceptions are associated with bony parts whose exact position it is difficult to determine with accuracy especially in a twelve-day old baby. We are surprised that the upper limb was not measured more precisely. Forearm length is our worst dimension and probably not as accurately measured as it should have been. Head dimensions on the whole were measured quite well though head height we feel is a little surprising but still we think quite reliable. Of the pelvic dimensions intercristal is the best. Table 2 lists the dimensions in the order of precision with which they were measured as revealed in the last column of table 1. We think the tables show that in all dimensions the precision obtained is such that there is no possibility of the differences in size of

TABLE 2

Dimensions in Order of Precision with which Measured

ORDER	DIMENSION	ORDER	DIMENSION
1	Total Body Length	17	Crown-Cristal
2	Head Length	18	Subocc.-Frontal Diam.
3	Head Width Maximum	19	Bi-Trochanteric
4	Subocc.-Vertex-Nasion-Arc	20	Crown-Sternal
5	Subocc.-Frontal Circ.	21	Bi-Deltoid
6	Crown Rump	22	Inter-spinous
7	Subocc.-Bregmatic Circ.	23	Knee Height
8	Subocc.-Bregmatic Diam.	24	Head Height
9	Crown-Pubic	25	Hand Length
10	Head Width Min.	26	Foot Length
11	Trochanteric Height	27	Nasion-Menton
12	Intercristal	28	Bi-Gonial
13	Auriculo-Vertex Arc	29	Arm Length
14	Bi-Malar	30	External Conjugate
15	Span	31	Forearm Length
16	Crown-Xiphisternal		

the babies observed in our series being at all accounted for by variability in the precision with which the dimensions were measured.

RESULTS

Before considering the results of this series it is to be noted that these infants were measured in a great majority of cases on the twelfth day—never earlier than the eleventh and never later than the fourteenth. They were all "normal" infants and they were all recorded by the obstetrician as "full-term". Any noted as "premature" or "overterm" were excluded. It is important to note these facts since the question what is a good criterion of maturity will arise in the discussion. The two sexes were considered independently so that sex differences might be noted but the influence of parity, if any, and presentation are not here taken into account.

In table 3 are given the results for this series. They include for each dimension the number of babies measured, sex, mean, probable error of the mean, standard deviation and coefficients of variability. Formulae derived from a consideration of the regression lines were then worked out. These regression lines were obtained in the following manner:— Scatter graphs were constructed for each dimension plotted against total body length. The mean for each centimeter class interval of total body length was then found and these means in turn were plotted against total body length. By inspection a curve of best fit was drawn. This was always a straight line and therefore its formula was of the general type $Y = aX + b$.

Table 4 shows these formulae for the various dimensions for each sex and compares our formulae with those of Scammon and Calkins for the foetal period.

The graphs themselves are shown in Figures 2 and 3. These graphs show the results in the case of the boys only. The results for the girls, as shown in the tables, did not differ in any marked degree from them and are therefore not shown graphically.

The two sets of formulae are perhaps not strictly comparable since in our series the sexes have been treated separately. Where Scammon and Calkins give two formulae for a dimension that for the later foetal period is compared with ours, and it is usually in those dimensions where these authors have found it necessary to use two formulae that important differences from our results are observed.

TABLE 3

Results for Series of 692 12-Day Old Babies

DIMENSION	SEX	NO. OF CASES	MEAN CM.	EM±	σ	100σ/M
Total Body Length	M	345	51.8	.0725	2.03	3.91
	F	327	50.9	.0708	1.86	3.65
Crown-Sternal	M	344	12.9	.0244	0.67	5.20
	F	322	12.7	.0262	0.70	5.51
Crown-Xiphisternal	M	345	19.7	.0480	1.30	6.60
	F	325	19.1	.0412	1.09	5.70
Crown-Cristal	M	345	27.6	.0513	1.40	5.07
	F	316	27.1	.0492	1.30	4.80
Crown-Pubic	M	343	31.2	.0583	1.60	5.13
	F	326	30.5	.0507	1.36	4.46
Crown-Rump	M	344	34.5	.0619	1.70	4.93
	F	327	34.0	.0559	1.50	4.41
Span	M	334	50.9	.0748	2.03	3.99
	F	316	49.7	.0758	1.90	3.82
Bi-Deltoid	M	344	13.0	.0330	0.90	6.92
	F	327	12.7	.0320	0.87	6.85
Bi-Trochanteric	M	342	9.1	.0190	0.52	5.71
	F	327	8.95	.0186	0.50	5.58
External Conjugate	M	342	6.1	.0157	0.43	7.05
	F	321	6.1	.0162	0.43	7.05
Intercristal	M	344	8.0	.0157	0.44	5.50
	F	327	7.9	.0156	0.41	5.20
Interspinous	M	345	7.8	.0152	0.43	5.51
	F	327	7.6	.0156	0.42	5.53
Arm Length	M	341	8.7	.0301	0.82	9.42
	F	325	8.6	.0311	0.83	9.65
Forearm Length	M	341	7.4	.0246	0.66	9.05
	F	325	7.2	.0247	0.66	9.16
Hand Length	M	340	6.7	.0168	0.46	6.87
	F	329	6.6	.0164	0.44	6.87
Height Trochanter	M	345	21.5	.0468	1.29	6.00
	F	326	21.3	.0462	1.24	5.82
Height Knee	M	345	10.6	.0348	0.96	9.06
	F	325	10.4	.0348	0.93	8.94
Foot Length	M	343	8.4	.0179	0.49	5.83
	F	326	8.2	.0168	0.45	5.49

TABLE 3 (*Continued*)

Results for Series of 692 12-Day Old Babies

DIMENSION	SEX	CASES NO. OF	CM. MEAN	EM±	σ	100σ/M
Nasion-Menton	M	343	4.75	.011	0.30	6.30
	F	327	4.70	.013	0.35	7.40
Bi-Malar	M	346	7.46	.013	0.37	4.96
	F	327	7.36	.014	0.35	4.75
Bi-Gonial	M	346	6.10	.020	0.55	9.00
	F	327	5.90	.018	0.47	7.96
Head Length	M	344	12.4	.019	0.53	4.31
	F	329	12.1	.017	0.46	3.80
Head Width Max.	M	346	9.5	.015	0.43	4.53
	F	327	9.3	.014	0.38	4.08
Head Width Min.	M	345	7.3	.014	0.39	5.34
	F	328	7.2	.012	0.36	5.00
Head Height	M	341	8.2	.015	0.42	5.12
	F	327	8.0	.014	0.39	4.87
Suboccip-Vertex-Nasion Arc	M	343	23.8	.055	1.50	6.30
	F	320	23.5	.049	1.30	5.53
Auriculo-Vertex Arc	M	342	23.0	.045	1.20	5.21
	F	325	22.5	.040	1.07	4.75
Suboccip-Frontal Circ.	M	343	33.5	.043	1.19	3.55
	F	325	32.9	.041	1.09	3.31
Suboccip-Frontal Diam.	M	345	11.4	.019	0.53	4.65
	F	327	11.1	.017	0.47	4.24
Suboccip-Bregmatic Circ.	M	344	32.9	.042	1.17	3.55
	F	325	32.3	.039	1.05	3.25
Suboccip-Bregmatic Diam.	M	346	10.6	.018	0.50	4.71
	F	326	10.4	.018	0.49	4.71
Weight at Birth (lbs)	M	341	7.6	.036	0.98	12.89
	F	327	7.3	.034	0.92	12.60
Weight at 12 days (lbs)	M	295	7.4	.034	0.88	11.90
	F	213	7.1	.036	0.89	12.53
Height Sitting-Height Index	M	343	66.4	.084	2.30	3.46
	F	325	66.6	.073	1.95	2.93
Face Index	M	345	63.6	.156	4.25	6.68
	F	326	63.8	.166	4.46	7.00
Head Length-Width Index	M	345	76.3	.127	3.50	4.59
	F	326	76.6	.117	3.14	4.10
Head Length- Height Index	M	342	66.3	.131	3.60	5.43
	F	325	66.4	.133	3.56	5.36

TABLE 4

Comparison of Formulae

MEASUREMENT	SEX	OUR FORMULAE	SCAMMON-CALKINS
		CH ± cm.	CH ± cm.
Crown-Sternal	M	.18 + 3.62	.24 +2.2
	F	.18 + 3.52	.....
Sternal-Xiphisternal	M	.10 + 1.725	.11 — .15
	F	.11 + 0.84	.....
Xiphisternal-Pubic	M	.30 — 4.0	.26 —1.6
	F	.285 — 3.11	.....
Pelvic Height	M	.23 — 5.08	.155 — .4
	F	.177 — 2.00	.....
Sternal-Pubic	M	.4 — 2.4	.28 +1.5
	F	.375 — 1.25	.....
Crown-Rump	M	.625 + 2.10	.66 + .5
	F	.56 + 5.54	.....
Bi-Deltoid	M	.21 + 2.04	.27 — .25
	F	.20 + 2.60	.....
Bi-Trochanteric	M	.17 + .33	.1775— .35
	F	.16 + .80	.....
External Conjugate	M	.095 + 1.20	.115 — .10
	F	.11 + .44	.....
Inter-Cristal	M	.11 + 2.30	.1625— .25
	F	.112 + 2.15	.....
Inter-Spinous	M	.112 + 2.0	.145 — .25
	F	.10 + 2.5	.....
Upper Limb Length	M	.46 — .86	.4 — .4
	F	.37 + 3.38	.....
Arm Length	M	.16 + .44	.155 — .05
	F	.16 + .44	.....
Forearm Length	M	.13 + .77	.13 — .15
	F	.155 — .70	.....
Hand Length	M	.10 + 1.6	.12 — .30
	F	.085 + 2.24	.....
Trochanteric Height	M	.37 + 2.38	.43 — .70
(lower limb length)	F	.35 + 3.40	.....
Knee Height	M	.21 — .26	.2 — .45
	F	.19 + .76	.....

TABLE 4 (*Continued*)

Comparison of Formulae

MEASUREMENT	SEX	FORMULAE	SCAMMON-CALKINS
		CH ± cm.	CH ± cm.
Foot Length	M	.125 + 2.00	.16 — .651
	F	.120 + 2.13	.....
Nasion-Menton	M	.072 + 1.04	.105 + .05
	F	.076 + .844	.....
Bi-Malar	M	.10 + 2.3	.1375+ .025
	F	.10 + 2.3	.....
Head Length	M	.158 + 4.23	.235 + .4
	F	.115 + 6.31	.....
Head Width Maximum	M	.10 + 4.3	.19 + .2
	F	.10 + 4.2	.....
Subocc-Vertex-Nasion Arc ...	M	.255 +10.77	.465 +1.5
	F	.23 +11.82	.....
Auriculo-Vertex Arc	M	.205 +12.07	.4675+1.10
	F	.19 +12.66	.....
Subocc-Frontal Circum.	M	.41 +12.175	.65 +1.5
	F	.3635+14.25	.....
Head Height	M	.075 + 4.35	.175 + .35
	F	.07 + 4.48	.....

It may be permissible to point out some of the salient features to be noted by an examination of the results of this series as revealed in table 3 and the graphs.

The weight of the male child at birth exceeds that of the female by 4 per cent. In neither sex has the baby at 12 days quite regained its birth weight. Both sexes lose weight and regain it at apparently the same rate.

In total body length the male child at 12 days exceeds the female by approximately 2 per cent. Since this is a linear record it would appear to be strictly comparable to the weight difference.

In all dimensions the male baby's measurements are in excess of those of the female; the dimensions in which the female most nearly approximates the male are the pelvic ones. In one case the means are the same. It is not, however, a very striking feature.

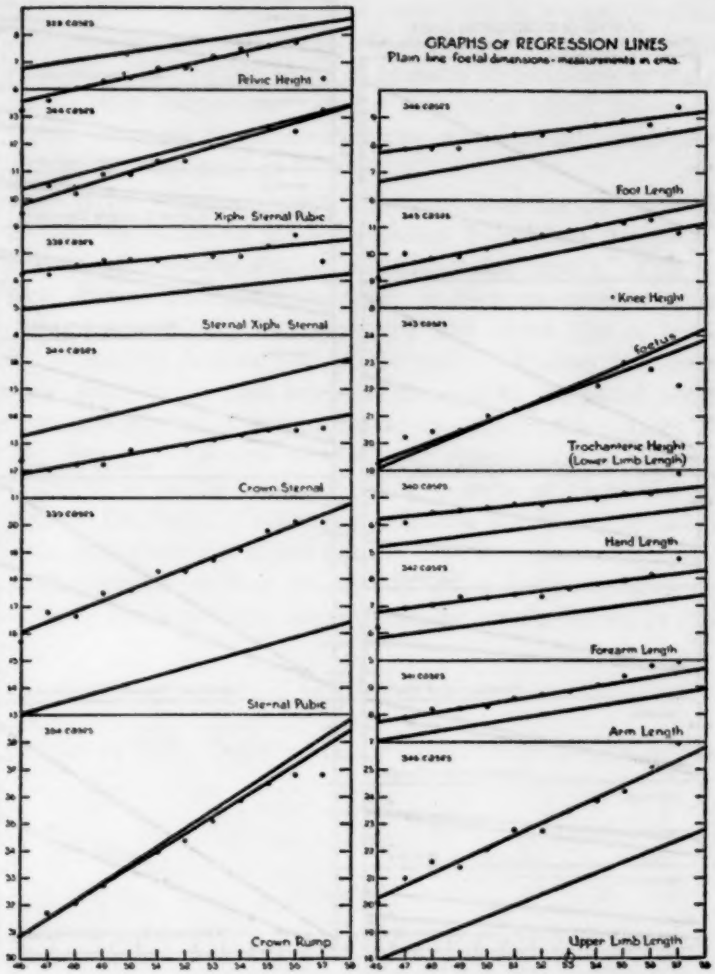

FIG. 2. COMPARISON OF REGRESSIONS OF VARIOUS DIMENSIONS OF 12-DAY OLD MALE INFANTS ON TOTAL BODY LENGTH WITH CORRESPONDING FOETAL REGRESSIONS

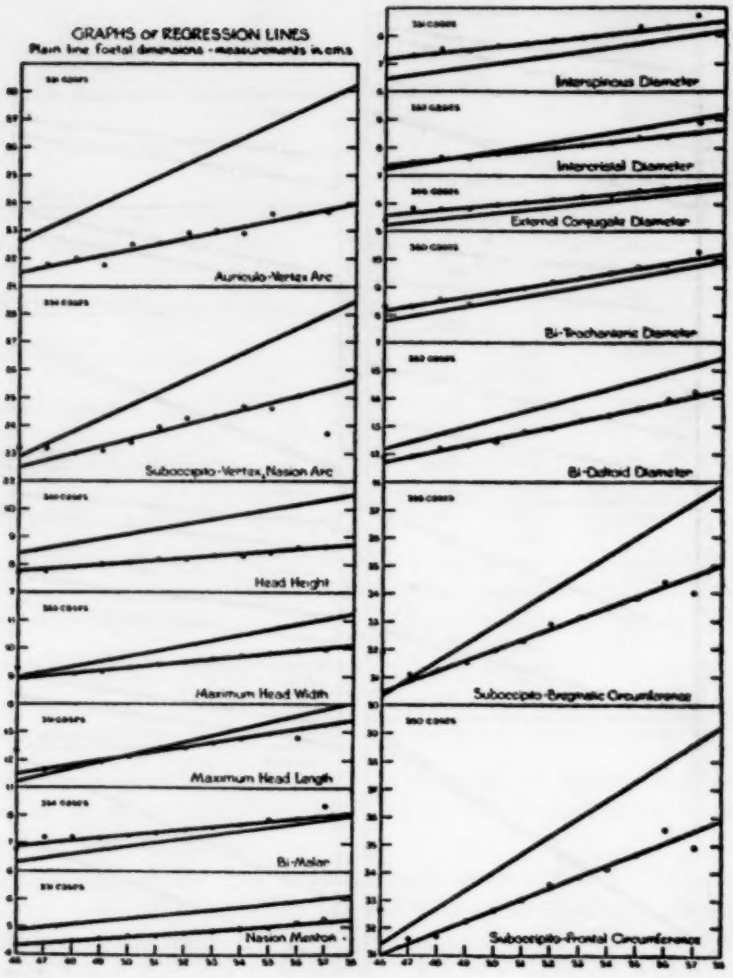

FIG. 3. COMPARISON OF REGRESSION OF VARIOUS DIMENSIONS OF 12-DAY OLD MALE INFANTS ON TOTAL BODY LENGTH WITH CORRESPONDING FOETAL REGRESSIONS

As a rule the male infant shows somewhat greater variability in its dimensions than the female. This variability is greater in the male in 23 dimensions; equal to the female in 3, and less than the female in 5 dimensions. The female seems to be more variable only in the pelvic and upper limb dimensions. If the differences noted between these and the other female dimensions are true ones then they seem to manifest themselves very early in life.

Again if the formulae of the regression lines are an indication of growth rate—a statement we shall discuss later—then the male baby is on the whole growing slightly faster than the female. This is true for most dimensions though generally in those in which the female shows greater variability the increment rate seems also to be faster than or at least as fast as, that of the male. Whether this increased increment rate of the male has held throughout the foetal period or not is not known, but it is seen during this small period under observation (from 46 to 58 cms. of total body length). It is obvious that these rates alter during post-natal development; at times the female rate exceeds the male. Further investigation is required to determine when and how these alterations occur.

An examination of how the various major body segments contribute towards the total body length gives the results shown in table 5.

TABLE 5

Percentage of Total Length of Major Segments and Increment Rates

DIMENSION	MEAN IN CM.		% FOR 1 CM. C. H. LENGTH		INCREMENT RATE		SCAMMON AND CALKINS
	M	F	M	F	M	F	
Crown-Sternal (head & neck)	12.9	12.7	.245	.245	.18	.18	.24
Sternal-Xiphisternal (thorax)	6.8	6.4	.13	.125	.10	.11	.11
Xiphisternal-Pubic (abdomen)	11.5	11.4	.22	.22	.30	.285	.26
Trochanter Height (lower limb)	21.5	21.3	.41	.41	.37	.35	.43
			A		B		C

These are given in percentage for 1 cm. of total body length and are derived from the means of the series. They are compared with our baby formulae on the one hand and the foetal formulae of Scammon and Calkins on the other, for each centimeter of body length. Constants are not included.

It will be seen that whilst the body proportions of the average 12 day baby (both male and female) are comparable to the proportions of an average infant, derived by projecting the foetal formulae into our period—cf. columns *A* and *C*—yet an inspection of the baby formulae shows that rate of increment has decreased somewhat in the head and neck, and lower limbs—cf. columns *A* and *B*. It has remained stationary in the thorax but has noticeably increased in the abdomen. This would seem to be of some significance and the query arises, when does the increment rate increase in the abdomen? When does it slow up in the head? From the fact that it was apparently necessary in the foetal period to use two formulae to represent abdomen increase, it seems that an increase in increment rate in this segment occurs in the foetal period at about 25 cms. of total body length, and we find a further increase has taken place by the time the limit of our series is reached. The formulae for foetal rate given by Scammon and Calkins are:—

5 to 25 cmso. of CH length... .19 CH (mm) plus 1.5 mm.
25 to 55 cms..... .26 CH (mm) minus 16.0 mm.

and ours are:—

46 to 57 cms. of CH length... .30 CH (mm) minus 40.0 mm.

This indicates a progressive increase in abdomen increment rate.

A similar state of affairs occurs in the head except that the phenomenon is reversed. It is one of slowing up. If our formulae are again compared with those for the foetal period it will be seen that there has been a very great slowing up of the rate of head increment. This is often almost 50 per cent (see table 4). One feels that the formulae for the head in the late foetal period are too high. They obviously do not fit the raw data nearly so well as they did in the early period and it seems to be for this reason that two formulae again are given for crown to sternal notch dimension (in which the head is largely involved). The second formula exhibits this slowing up phenomenon though even this formula seems too high. We feel that head increment rate slows up quite remarkably in the late foetal period. Where

dimensions are concerned with both head and trunk involved (e.g. crown-rump), the decrease in head increment rate is in part balanced by increase in abdomen increment rate and one straight line relationship for the whole dimension fits the raw data quite well in consequence. But it does not tell the whole story.

Comparisons with the formulae for the foetal period suggest little difference in the rate of increment of the upper limb. The foetal formulae and ours are quite comparable. The lower limb also seems to be increasing in length slightly less rapidly than during the foetal period. The same is true of the transverse body dimensions and the face. It is then only in the abdomen that we find an actual increase in increment rate over the foetal period, and it is the head alone that exhibits in any marked degree a decrease in rate.

An investigation of 754 adult females gives the measurements for the major body segments shown in table 6.

TABLE 6

Comparison of 754 Adults (F) and 327 Infants (F)

DIMENSION	ADULTS MEAN CM.	INFANTS MEAN CM.	% FOR 1 CM. TOTAL HT. ADULT	% FOR 1 CM. C. H. LENGTH INFANT	FORMULA
Total Body Length ...	158.5	50.9	...	...	...
Crown-Sternal	30.0	12.7	.19	.245	.18
Sternal-Pubic	48.3	17.8	.305	.345	.395
Trochanter Height ...	80.2	21.3	.505	.41	.35

These are taken from the means of the series and are computed in percentage for each cm. of total height, and then compared with the female infant series. This series incidentally consists of the mothers of our infants.

The head and neck proportions are less than in the average 12 day baby (cf. .19 adult with .245 infant); the latter, however, has already established, it would seem, a new and slower increment rate, which, if continued to the adult period would practically give the proportions seen (cf. .19 adult with .18 infant). The trunk proportions are also

less (cf. .305 adult with .345 infant), and the increment rate still has to fall (cf. .305 adult with .395 infant), although it is maintaining well its foetal rate in our series. It even slightly exceeds it, due it would seem to increased increment rate in the abdomen. The lower limb, however, is greatly in excess in the adult (cf. .505 adult with .41 infant) and the infant increment rate must again greatly increase (cf. .505 adult with .35 infant), although it seems temporarily in our period to have fallen off somewhat.

By the twelfth day the female height-sitting height index is already slightly greater than the male, (or the female trunk is relatively longer) which of course is the adult condition. A study of 30 children showed that this index, which is 66.4 at 12 days, at 4 years has become 57.5, approaching rapidly the adult index 52.3. In early years therefore the lower limb grows rapidly.

In conformity with increase in increment rate in the abdomen it will be seen that pelvic increment rate (pelvic height) shows a noticeable increase and an examination of crown-rump shows the abdomen increase about making up for the decrease in the two segments above it.

The female head is slightly more brachycephalic and slightly more hypsicephalic than the male. This brachycephalism of the female agrees with Kugler's results (2) although our indices are somewhat lower in both sexes, due probably to the difference in racial types of the two series. It is interesting to observe that in the infant the head length

TABLE 7

Comparison of Head and Face Dimensions of Adult, Child of 4 Years and Infant

DIMENSION	754 FEMALE ADULTS	30 CHILDREN OF 4 YRS.	327 FEMALE INFANTS	% INCREASE TO REACH ADULT 30, 4 yrs.	327 infants
Head Length Max. ..	18.1	17.8	12.1	1.7	50.0
Head Width Max. ...	14.2	13.7	9.3	3.6	52.7
Head Height	12.2	12.4	8.0	...	52.5
Nasion-Menton	10.6	8.4	4.7	26.2	125.5
Bi-Malar	11.7	10.9	7.4	7.3	58.0
Bi-Gonial	9.7	8.2	5.9	18.3	64.4

and height bear the same relationship to one another as the total body length and crown-rump.

A study was made of the head proportions of the same 754 adult females. These are shown in table 7 with the infant series and the percentage increase required to bring baby head measurements to the adult dimensions.

In this table are also shown the average head dimensions for 30 children aged 4 years. These latter dimensions closely approximate the adult dimensions. The rate of increment in the very early years therefore is very great (although as pointed out much slower than the foetal rate). Further it may be remarked that the percentage increase required to bring the infant head up to adult proportions is practically the same (50 per cent) for each of the three major dimensions.

Reference to the same table reveals that the face shows a great increment in the first four years but still falls short of adult proportions. Again the bi-malar width—which is more intimately associated with the head than with the face—more nearly approximates adult measurements at four years than do the essential face dimensions. The face of the infant again however is not showing as great a rate of increment as it did in the foetal period.

Throughout this series we have been dealing with babies all of the same chronological age, and yet when each dimension in the series is plotted in turn against total body length the results give regression lines entirely comparable to the phenomena exhibited by a series of different age foetuses. They show, in other words, the same pattern of increment as is manifested by one infant growing in total body length from 46 to 58 cms. The phenomena therefore would appear to be not those of variability in dimensions of a series of infants of the same maturity but true growth phenomena. And yet they are all 12 day old babies. Obviously chronological age is not any particular criterion of maturity in the very young. Birth occurs independently of maturity, and it would seem from our results as if total body length is a much better criterion of maturity, just as truly in the small range (46-58 cms) that represents the period of birth, as it is in the foetal period. The varying stages of maturity at which birth occurs must be take into account in evaluating the various phenomena of development, both physical and mental, which we are accustomed to relate almost entirely to chronological age. We suggest therefore that total

body length, at least in the very early period of post-natal life, is a more reliable measure of maturity than age from birth.

SUMMARY

1. The average measurements for over 30 dimensions are given for a series of 700 twelve-day old babies.

2. Formulae of increment rates for each dimension are worked out and compared with those for the foetal period.

3. The sexes are compared. Males are more variable and on the whole exhibit a slightly greater increment rate.

4. Increment rates in the various segments of the body alter from time to time. Abdomen rate in this period is increasing. Head rate is slowing up markedly, and there is in general a slowing up.

5. Chronological age is not the best criterion of maturity in the young infant. It is less reliable than total body length.

LITERATURE CITED

1. Scammon, Richard E., and Leroy A. Calkins. 1929. The Development and Growth of the External Dimensions of the Human Body in the Fetal Period. Univ. of Minnesota, *Minneapolis*. 367 pp. (This contains a full bibliography, pp. 294-307)

2. Kugler, Erica. 1932. Körperproportionen und Kopfform bei Neugeborenen. Anthrop. Inst. Univ. Zurich, *Zurich*.

FURTHER OBSERVATIONS ON COLOR BLINDNESS AMONG NEGROES WITH GENEALOGIC AND GEOGRAPHIC NOTES*

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PROBABLY the earliest recorded case of color blindness is that described to Priestley (1733-1804), by a Mr. Huddart in 1777, (Carter, '90). This was apparently congenital, for the subject had a color blind brother. The description of red-green blindness in the celebrated chemist Dalton (1766-1844) soon gave to the defect the temporary name "daltonism," and served to focus attention upon it.

A large number of studies, summarized by Clements ('30), indicate that there are racial differences in the incidence of color blindness. More recent reports by Garth ('33) on American Indians, Whites, Negroes and Jews, by Kilborn and Beh ('34) on Chinese and by the writer on American Negroes ('34) also support this view.

We have thus far given the Ishihara test for color blindness to 2,741 American Negroes, 2,019 males and 722 females. The subjects ranged in age from 7 to 70, and were tested individually, one eye at a time, then both eyes together. Most were tested with the Ishihara plates fastened at eye level at distances of from two to five feet in evenly diffused daylight. A large number of the later subjects have been tested also with the plates used as a book, placed on a table, at which the subject sat, the eye-to-book distance being always less than 18 inches. A slight difference in results obtained from these two methods is discussed below.

In our earlier report on 1,628 men, 61 or 3.75 per cent were color blind. We have since observed 391 new subjects, among whom were 18 cases of color blindness. Of the entire group of 2,019 men, there-

*Presented in condensed form before the Virginia Academy of Science, Richmond, Virginia, May 3, 1935.

fore, 79 or 3.91 per cent are color blind. The incidence of green blindness, 2.87 per cent, and that of red blindness, 1.04 per cent, are in the ratio of almost 3:1, as was found by von Planta ('28), Miles ('29), and Clements ('30) in other racial groups. On subsequent days we tested the 18 men, color blind to the plates at table level, with the plates at eye level more than 60 inches away, and found 4 not color blind.

Miles ('29) also noted that a few of his color blind cases showed better ability to read the test numbers at ten feet than at four, "thus indicating greatly restricted color fields, which are practically confined to the fovea," since the image of the test number occupies a smaller area on the retina the further the observer stands from the plates.

When our figures are combined with those of other reports, we find a total of 119 color blind males in 3,134 American Negroes, or an average color blindness incidence (C. B. I.) of 3.75 per cent.

In an earlier report we found no color blindness in 651 females. We have since tested 71 other women and found one incompletely color blind subject. Combined with other figures, this gives an average C. B. I. for American Negro females as 0.36 per cent.

Some of the more recent* reports are shown in Table 1.
[Tables of earlier results may be found in Clements' paper ('30).]

RACIAL MAKE-UP

The term "American Negro" requires some qualification.

"A foreigner might go over the literature of the Negro problem and come to believe that there are in the United States facing each other today, two absolutely unmixed groups of whites and blacks. Yet, nothing is further from the truth. The so-called American Negro is probably less than 25 per cent of pure African descent." (DuBois, 1928.) Clements ('30) apparently realized this when he grouped his 323 Connecticut Negro subjects into 118 "obviously mixed" and 205 "probably full bloods."

As we collected our data for the determination of C. B. I., DuBois' statement and Clements' hint became so significant that we have attempted to study the racial mixture of our subjects.

We made family trees and noted the locality in which each subject lived, hoping also to determine whether or not geographic situation was of any significance, for we noted that our figures for Negroes mainly from the South (3.75 per cent) agreed closely with

*Since this paper went to press, Garth has reported a C. B. I. of 5.3 per cent for male Turks (24 in 473) and 0.0 per cent for 217 females (*Science* 84:85).

TABLE 1

Racial Differences in Color Blindness Incidence

RACIAL GROUP	MALES			FEMALES			AUTHOR
	Tested	Colorblind		Tested	Colorblind		
	No.	No.	%	No.	No.	%	
Chinese	1115	67	6.3	...	..	..	Kilborn and Beh ('34)
Chinese	1164	80	6.9	1132	19	1.7	Chang ('32)
Indians (unspec., full bloods)	392	8	2.0	...	..	..	Clements ('30)
Indians (unspec., full bloods)	562	14	2.5	337	0	0	Garth ('33)
Indians (mixed)..	232	3	1.2	...	..	..	Clements (l.c.)
Indians (mixed)..	480	25	5.2	523	4	0.8	Garth ('33)
Jews	200	8	4.0	175	0	0	Garth ('33)
Mexicans	571	13	2.3	...	..	..	Garth ('33)
Mexicans (immigrant) ...	523	13	2.5	...	..	..	Garth ('33)
Navajos (full bloods)...	535	6	1.1	456	3	0.7	Garth ('33)
Amer. Negroes (Conn.)	323	12	3.7	...	..	..	Clements
Amer. Negroes (Colorado?) ...	254	7	2.8	165	0	0	Garth
Amer. Negroes (South)	538	21	3.9	496	4	0.8	Garth
Amer. Negroes (South)	1628	61	3.75	651	0	0	Crooks ('34)
Whites (U.S.) ...	1286	106	8.2	436	?	0.9	Miles ('29)
Whites (U.S.) ...	448	35	7.8	487	?	1.6	Haupt ('22)
Whites (U.S.) ...	795	67	8.4	200	8	4.0	Garth
Whites (Europe)	2000	159	7.95	3000	?	0.4	von Planta ('28)

TABLE 2

Racial Make-up of 1638 "American Negroes"

GROUP NAME	MEN (NOT COLORBLIND)		WOMEN (NOT COLORBLIND)		HERSKOVITS' N.Y.C.-W.VA-HOWARD GROUP
	No.	Percent	No.	Percent	Percent
Unmixed Negro*	171	15.2	57	12.1	22.0
Negro plus Indian.....	149	12.7	12	2.5	6.3
More Negro than White..	333	29.1	135	28.6	24.8
More Negro than White plus Indian	234	20.6**	118	25.0	6.9**
About same Negro and White	151	12.7	66	13.9	16.7
About same Negro and White plus Indian	28	2.4	37	7.8	8.5
More White than Negro	51	4.2	36	7.8	9.3
More White than Negro plus Indian	49	3.0	11	2.4	5.5
Total	1166	99.9%	472	100.1%	100.0%

*It might be of interest to note that, according to their own statements, there are among our subjects, third and fourth generation offspring (and later) of a famous frontiersman, a well-known printer-scientist, a U. S. President, and of persons related to the so-called "royal family of the United States." We follow Herskovits by considering as unmixed, those subjects who knew three grandparents to be full blooded even if they knew nothing about the racial make-up of the fourth grandparent.

**It will be observed that the percentage of our subjects with Indian admixture is larger than that in Herskovits' Harlem-Howard group. This is probably due to the fact that 42.17 per cent of our Negroes are from Virginia (26.27 per cent) and North Carolina (15.9 per cent), in which localities Indians and Negroes are well known to have intermarried freely.

those for Connecticut Negroes (Clements: 3.7 per cent) and those for other Southern Negroes (Garth: 3.9 per cent) but differed from the frequency for the Colorado Negroes of the latter investigator (2.8 per cent).

Of the total of 2,019 male American Negroes tested for color blindness, 1,166 or 57.7 per cent were able to give some information about their parents and grandparents at least. From genealogical diagrams, we estimated the amount of race mixture in each and grouped them, according to Herskovits' ('28), into eight classes. Of the 722 women, 472 or 65.37 per cent supplied information for family trees. These were also grouped into Herskovits' eight classes. The results are summarized in Table 2, and compared with Herskovits' findings on his sample from Harlem, West Virginia and Howard University.

The color blind men were also grouped, somewhat less accurately, according to Herskovits' eight classes as follows:

TABLE 3

Racial Make-up of 79 Color Blind Men

GROUP NAME	NUMBER OF MEN	PER CENT
Unmixed Negro	9	11.4
Negro plus Indian	5	6.4
More Negro than White	16	20.4
More Negro than White plus Indian.	25	31.6
About same Negro and White	14	17.5
About same Negro and White plus Indian	10	12.8
More White than Negro	0	0
More White than Negro plus Indian..	0	0
	79	100.1%

The only color blind woman found falls in the category "More White than Negro."

GEOGRAPHIC DISTRIBUTION

When the normal group and the color blind were studied for geographic distribution we found the following:

TABLE 4

Geographic Distribution (Men)

GEOGRAPHIC AREA	NORMAL GROUP	COLOR BLIND GROUP	
New England and New York.....	5.52%	2	2.5%
Middle Atlantic States	58.0 %	51	64.6%
Southern States (including Texas)	28.89%	18	22.7%
Midwestern States	7.25%	8	10.1%
	99.66%	79	99.9%

It will be seen that the color blind subjects are distributed among these arbitrary geographical divisions in somewhat the same ratios in which the members of the normal group are distributed. When this result is compared with the fact that von Planta's report for European Whites agrees closely with those of Clements' and the others (see Table 1) for American Whites, and with the similarity of findings of Garth and of Clements for Indians in different parts of the country, it seems that locality has no influence on the incidence of color blindness.

When we note, however, that in spite of a complex genetic make-up, the American Negro as a group presents a C. B. I. that is distinct, but is yet uniform in the localities investigated, we feel with Herskovits' ('28) that though

"the American Negro resembles all his ancestral types, yet he is none of them. He is distinctive among human beings. There are in his ancestry all of the principal racial elements of which humanity is composed, White, Negro and Mongoloid. But from this mixture there is being welded, and is already discernible, a definite physical (and physiologic) type, which may (truly) be called the American Negro. (He)...is not like any type from which (he) has come. (He) is not White. (He) is not Negro; (he) is not Mongoloid. (He) is all of them and none of them."

The American Negro is a new type, an "amalgam" but a constant, uniform biologic entity.

Only a few of the color blind cases were aware of their defects. Many still do not believe that they are color blind, and no wonder, for though designated defective by the Ishihara charts, they can identify various colors. Yet Kepner ('05) found that certain primitive peoples of the Philippines have no native names for colors other than red and yellow, light and dark, black and white, the names for other colors, green for example, being of Spanish origin. We have found a well developed hue discrimination among our color blind cases. Different shades of green, red, blue and yellow are all identified with correct names in a large majority of the subjects questioned, whereas a number of normals confuse the *naming* of blues and greens, reds and yellows.

These observations lead one to suppose that as the young child learns colors and color names by observation and imitation, a natural defect in color vision may serve automatically to train into it carefulness of observation and keenness in the selection of words, which may well "carry over" into other fields. The brilliance of Dalton, perhaps the best known color blind subject, may be a case in point, but the investigation of the correlation between intelligence and color blindness is a job for the psychologists.

SUMMARY

1. Ishihara's tests for color blindness have been administered to 2,741 American Negroes of both sexes, age 7 to 70. Two thousand and nineteen were males and 722 females.

2. The color blindness incidence for our Negro males was 3.91 per cent (79 cases); for our Negro females 0.14 per cent, (1 case).

3. There are distinct and definite racial differences in the incidence of color blindness.

4. The American Negro is apparently a new racial entity with its own constant C. B. I.

5. Geographic location apparently has no influence on the C. B. I. of a racial group.

6. Green blindness was found to be three times as common as red blindness, in men.

BIBLIOGRAPHY

1. CARTER, R. B. 1890. Color vision and color blindness. *Nature*, 42: pp. 55 ff.
2. CHANG, S. P. 1932. Statistics on color blindness among students in Peiping. *Nat. M. J. China*, 18: 806 (Quoted from Kilborn and Beh).
3. CLEMENTS, F. 1930. Racial differences in color blindness. *Am. Jour. Phys. Anthrop.*, 14: 4, July-September.
4. CROOKS, K. B. M. 1934. Notes on color blindness among Negroes. *Am. J. Phys. Anthrop.*, 19: 3, 453. Oct.-Dec.
5. DUBOIS, W. E. B. 1928. The American Negro. *Annals Am. Acad. Pol. Soc. Sci.*, 140: pp. 6-10.
6. GARTH, T. H. 1933. The incidence of color blindness among races. *Science*, 77: 333-4.
7. HAUPT, I. 1926. The Nela test for color blindness applied to school children. *Jour. Comp. Psychol.*, 6: 291.
8. HERSKOVITS, M. J. 1928. The American Negro. A. A. Knopf. *New York.*
9. ISHIHARA, SHINOBU. Tests for colour blindness. Sixth Edition. Kanehara, *Tokyo* (Sole U. S. Agents: C. H. Stoelting, Chicago.)
10. KEPNER, W. A. 1905. Observations on color perception among the Visagans of Leyte Island, P. I. *Science*, 22: 680-2, Nov. 27.
11. KILBORN and BEH, 1934. Color blindness among the Chinese. *Science*, 79: 34.
12. MILES, W. R. 1929. One hundred cases of color blindness detected by the Ishihara test. *Jour. Gen. Psychol.*, 2: 535-543.
13. VON PLANTA, P. 1928. Die Häufigkeit der angeborenen Farbensinnstörungen bei Knaben und Mädchen durch die üblich klinischen Proben. *Arch. f. Ophth., Leipzig*, 120: 253.

RECENT LITERATURE

USEFUL IN THE STUDY OF HUMAN BIOLOGY

In this department will be noticed the books and reprints which are currently received at the Editorial Office. Publications intended for notice here should be addressed to Dr. Raymond Pearl, Department of Biology, School of Hygiene and Public Health, 1901 East Madison Street, Baltimore, Maryland, U. S. A.

I. EVOLUTION AND GENETICS

1. *Evolution—General Principles*

HESSE, RICHARD. Abstammungslehre und Darwinismus. *Leipzig* (B. G. Teubner), 1936. Pp. iv + 108. 9 × 6⅛ inches. 4.20 marks (Germany); 3.15 marks (outside Germany).

MCATEE, W. L. The Malthusian principal in nature. *Scientific Monthly*, Vol. 42, pp. 444-456, 1936. [Bibliography of 64 titles.]

MCCRADY, EDWARD. Reason and Revelation. Argument for the Truth of Revealed Religion Based Solely upon the Evidences of Science and Philosophy. *Grand Rapids* (Wm. B. Eerdmans Publishing Co.), 1936. Pp. 411. 9 × 6 inches. $3.00. [Bibliography of 3½ pages.]

MORGAN, THOMAS HUNT. Modern views of the evolution theory. *American Scholar*, Winter, 1935, pp. 14-22.

PLEYDELL-BOUVERIE, C. Objective Evolution. *London* (Williams and Norgate), 1936. Pp. 233. 8½ × 5½ inches. 7s. 6d.

SHULL, A. FRANKLIN. Evolution. *New York* (McGraw-Hill Book Co.), 1936. Pp. x + 312. 9 × 5⅞ inches. $3.00. [Bibliography of 9½ pages.]

UNGERER, E. Zeit-Ordnungsformen des Organischen Lebens. *Bios*, Bd. 5. *Leipzig* (Johann Ambrosius Barth), 1936. Pp. vi + 72. 9¼ × 6¼ inches. 4.50 marks (paper). [Bibliography of 2 pages.]

2. *Human Evolution*

KROGMAN, W. M. Tiber the birthplace of the Plains Indian? *Zeitschrift für Rassenkunde*, Bd. 3, pp. 202-203, 1936.

KUMARIS, J. Zur Primateneinteilung. *Zeitschrift für Rassenkunde*, Bd. 3, pp. 203-204, 1936.

KUMARIS, J. Noch ein Wort zur Primateneinteilung. *Zeitschrift für Rassenkunde*, Bd. 3, pp. 311-312, 1936.

LEBZELTER, VIKTOR. Zur Altersfrage der ostafrikanischen Menschenfunde. *Zeitschrift für Rassenkunde*, Bd. 3, p. 202, 1936.

PETERS, H. B. Ergänzendes zur Primateneinteilung. *Zeitschrift für Rassenkunde*, Bd. 3, p. 205, 1936.

WARDEN, CARL J. The Emergence of Human Culture. *New York* (The Macmillan Co.), 1936. Pp. x + 189. 7⅛ × 5½ inches. $2.00. [Bibliography of 87 titles.]

3. *Prehistory and Archaeology*

HEINE-GELDERN, ROBERT v. Zur Rassen- und Urgeschichte Indiens. *Zeitschrift für Rassenkunde*, Bd. 3, pp. 248-252, 1936. [6 bibliographic footnotes.]

MCGREGOR, JOHN C. Ball courts in northern Arizona? *Museum Notes* (*Museum of Northern Arizona*). Vol. 8, pp. 55-58, 1936. Ten cents. [Bibliography of 2 titles.]

4. *Genetics—General Principals*

BARTLETT, M. S. and J. B. S. HALDANE. The theory of inbreeding with forced heterozygosis. *Journal of Genetics*, Vol. 31, pp. 327-340, 1935. [Bibliography of 4 titles.]

DANTCHAKOFF, VERA. Déterminisme et Réalisation dans le Devenir du Sexe. *Actualités Scientifiques et Industrielles*, 300. *Exposés de Biologie* (*La Cellule Germinale dans l'Ontogenèse et l'Évolution*), V. *Paris* (Hermann et Cie), 1935. Pp. 74. 10 × 6½ inches. 18 francs (paper). [Bibliography of 14 titles.]

GUYÉNOT, ÉMILE. La Détermination du Sexe et l'Hérédité. *Actualités Scientifiques et Industrielles*, 258. *Exposés de Biologie* (*La Cellule Germinale dans l'Ontogenèse et l'Évolution*), II. *Paris* (Hermann et Cie), 1935. Pp. 79. 10 × 6½ inches. 20 francs (paper).

LINDEGREN, CARL C. Genetical studies of bacteria. I. The problem of the bacterial nucleus. *Zentralblatt für Bakteriologie, Parasitenkunde und Infektionskrankheiten*, Bd. 92, pp. 41-48, 1935. [Bibliography of 29 titles.]; II. The problem of bacterial variation. *Ibid.* Bd. 93, pp. 113-122, 1935. [Bibliography of 23 titles]; III. Original of G-type colonies by transgeneration. *Ibid.* Bd. 93, pp. 389-400, 1936. [Bibliography of 4 titles.]

ROBSON, G. C. and O. W. RICHARDS. The Variation of Animals in Nature. *New York* (Longmans, Green and Co.), 1936. Pp. xvi + 425 + 1 plate. 8¾ × 5¾ inches. $8.25. [Bibliography of 26 pages.]

STRÖER, W. F. H. The gene, its function and its meaning in genetics. *Quarterly Review of Biology*, Vol. 11, pp. 57-69, 1936. [Bibliography of 55 titles.]

5. *Human Heredity*

CUMMINS, HAROLD and MORRIS STEGGERDA. Finger prints in a Dutch family series. *American Journal of Physical Anthropology*, Vol. 20, pp. 19-41, 1935. [Bibliography of 15 titles.]

FRETS, G. P. Die Familie AB. Nachtrag zu: Die Familie AA. Eine Familie mit mehreren Geisteskranken. *Zeitschrift für die gesamte Neurologie und Psychiatrie*, Bd. 152, pp. 98-106, 1935. [1 bibliographic footnote.]

FRETS, G. P. Heredity of eye color in man. *Eugenical News*, Vol. 20, pp. 1-3, 1935.

HALDANE, J. B. S. The rate of spontaneous mutation of a human gene. *Journal of Genetics*, Vol. 31, pp. 317-326, 1935. [Bibliography of 11 titles.]

JUSATZ, H. J. Blutgruppenzugehörigkeit der Rwala-Beduinen. *Zeitschrift für Rassenkunde*, Bd. 3, p. 315, 1936.

KÄSSBACHER. Ahnengeschwistertafeln. *Ärztliche Rundschau*, Nr. 8, pp. (of reprint) 2, 1935.

KRIEG, H. Die Biologie und Soziologie der Mischlingsbevölkerung von Paraguay. *Zeitschrift für Rassenkunde*, Bd. 3, pp. 113-128, 1936. [Bibliographic footnotes.]

MITTMANN, OTFRID. Kann durch den Faktorenaustausch ein Sterilisierungserfolg verhindert werden? *Zeitschrift für Rassenkunde*, Bd. 3, pp. 292-301, 1936.

PEARL, R. On the incidence of tuberculosis in the offspring of tuberculous parents. *Zeitschrift für Rassenkunde*, Bd. 3, pp. 301-307, 1936. [3 bibliographic footnotes.]

SCHULZ, BRUNO. Methodik der medizinischen Erbforschung. Unter besonderer Berücksichtigung der Psychiatrie. *Leipzig* (Georg Thieme), 1936. Pp. 189. 10 × 6¾ inches. M. 10.50 (paper); M. 12 (cloth). [Bibliography of 9 pages.]

STEGGERDA, MORRIS. Some results of a family history study. *A Decade of Progress in Eugenics, Scientific Papers*, 1932, pp. 425-430.

STRÖER, W. F. H. Familiäres Auftreten von Reihen erblicher Hand- und Fussabweichungen. *Der Erbarzt*, No. 2, pp. 22ff. (14 pp. of reprint), 1936. [Bibliography of 14 titles.]

6. *Eugenics*

AMERICAN EUGENICS SOCIETY, Inc. A Eugenics Program for the United States. *4 Hillhouse Ave., New Haven, Conn.* (George R. Andrews, Exec. Secy.), no date. Pp. 17. 7¾ × 4¾ inches.

FRETS, G. P. Sterilisatie in de psychiatrie. *Nederl. Tijdschrift voor Geneeskunde*, Jaarg. 78, pp. 5321-5332, 1934. [2 bibliographic footnotes.]

HUNTINGTON, ELLSWORTH (in conjunction with the Directors of The American Eugenics Society). Tomorrow's Children. The Goal of Eugenics. *New York* (John Wiley and Sons), 1935. Pp. x + 139. 8 × 5½ inches. $1.25. [Bibliography of 5 pages.]

STEGGERDA, MORRIS. Some eugenical aspects of the Indians of Piste, Yucatan. *Science*, Vol. 82, p. 616, 1935.

II. GROUP BIOLOGY

1. *Environment of Man*

BRUES, CHARLES T. The food of insects viewed from the biological and human standpoint. *Psyche*, Vol. 37, pp. 1-14, 1930.

CHENG, LIBIN T., H. TAO and C. K. CHU. A study of the winter dietary in Nanking. *Contributions from the Biological Laboratory of the Science Society of China*, Vol. 10, Zoological Series, No. 6, pp. 297-302, 1935. [Bibliography of 7 titles.]

FAIRGRIEVE, J., and ERNEST YOUNG. Human Geography. The Pacific Lands. *London* (George Philip and Son), 1936. Pp. iv + 226. 7⅛ × 4¾ inches. 2s. 6d. net.

IVES, JAMES E., ROLLO H. BRITTEN, DAVID W. ARMSTRONG, W. A. GILL and FREDERICK H. GOLDMAN. Atmospheric Pollution of American Cities for the Years 1931 to 1933, with Special Reference to the Solid Constituents of the Pollution. *U. S. Treasury Department, Public Health Service. Bulletin* No. 224. *Washington,* (United States Government Printing Office), 1936. 10 cents (paper). [Bibliography of 2 pages.]

JARVIS, CLARENCE S., and others. Floods in the United States. Magnitude and Frequency. (Planned in collaboration with the Water Planning Committee of the National Resources Board and its predecessor the Mississippi Valley Committee). *U. S. Department of the Interior, Geological Survey.. Water-supply Paper 771. Washington* (U. S. Government Printing Office), 1936. Pp. 497 + 3 folding plates. 9⅛ × 5⅞ inches. $1.00 (paper). [Bibliography of 207 titles.]

MILLS, C. A. The human background of air conditioning. *Vital Speeches of the Day,* Vol. 2, No. 10, pp. 307 ff., 1936.

PETERSEN, WILLIAM F. and MARGARET E. MILLIKEN. The Patient and the Weather. Volume I, Part 2, Autonomic Integration. *Ann Harbor, Mich.* (Edwards Bros.), 1936. Pp. xxx + 781 + 2 folding charts. 10¾ × 8¼ inches. $9.00. [Bibliography throughout.]

SCHOENICHEN, WALTER. Urdeutschland. Deutschlands Naturschutzgebiete in Wort und Bild. Lieferungen 15, 16. *Neudamm* (J. Neumann), 1936. Pp. (Lief. 15) 49-72 + 9 plates; (Lief. 16) 73-96 + 9 plates. 2 marks each (paper).

SCHOENICHEN, WALTER. Urdeutschland. Deutschlands Naturschutzgebiete in Wort und Bild. Lieferungen 17, 18, 19. *Neudamm* (J. Neumann), 1935. Lief. 17, pp. 97-120 + 9 plates; Lief. 18, pp. 121-144 + 9 plates; Lief. 19, pp. 145-168 + 8 plates. 10¾ × 8¼ inches. 2 marks each (paper).

STEFANSSON, VILHJALMUR. Adventures in Diet. *Chicago* (Institute of American Meat Packers), no date. Pp. 38. 9 × 6 inches. [Bibliography of 22 titles.]

TEXAS Almanac and State Industrial Guide. Since 1857. Texas Centennial Edition. *Dallas* (The Dallas News), 1936. Pp. 512 + folding map. 8½ × 5¾ inches. 50 cents; 65 cents postpaid (paper).

WHITE, C. LANGDON and GEORGE T. RENNER. Geography. An Introduction to Human Ecology. *New York* (D. Appleton-Century Co.), 1936. Pp. x + 790 + 1 folding chart. 8¾ × 6 inches. $4.00. [Bibliographic references throughout.]

2. Public Health and Hygiene

ADVISORY COMMITTEES ON MATERNAL AND CHILD WELFARE SERVICES Under the Social Security Act; Meeting of. *Journal of the American Medical Association,* Vol 106, pp. 51-53, 1936.

ATWATER, REGINALD M., and H. R. O'BRIEN. Cattaraugus County Department of Health. Thirteenth Annual Report for the Year Ending December 31, 1935. *Olean, N. Y.* Pp. 75. 9× 6 inches.

BRITISH COLUMBIA, Province of. Twenty-Fourth Report of the Medical Inspection of Schools for the Year Ended June 30, 1935. *Victoria,* 1936. Pp 35. 10½ × 7½ inches.

CUMMING, HUGH S. Chronic disease as a public health problem. *Milbank Memorial Fund Quarterly*, Vol. 14, pp. 125-131, 1936.

FAUGHT, FRANCIS A. Period health examinations. Counselling—Essential points in reporting to the examinee—The follow-up and the reexamination. *Weekly Roster and Medical Digest*, Vol. 31, pp. 1094-1096, 1936.

LEAGUE OF NATIONS. Report of the Pan-African Health Conference held at Johannesburg, November 20th to 30th, 1935. *League of Nations. Quarterly Bulletin of the Health Organisation.* Vol. 5, No. 1, pp. 1-209, 1936. *Geneva* (League of Nations); *New York* (World Peace Foundation). 9½ × 6⅛ inches. 65 cents (paper).

LENROOT, KATHARINE F. Advancing the health and welfare of the nation's children through federal and state cooperation. *Milbank Memorial Fund Quarterly*, Vol. 14, pp. 132-142, 1936.

PARRAN, THOMAS. Health security. *Milbank Memorial Fund Quarterly*, Vol. 14, pp. 113-124, 1936.

RANDALL, MARIAN G. How much work can a rural public health nurse do? *Milbank Memorial Fund Quarterly*, Vol. 14, pp. 163-172, 1936. [Bibliographic footnotes.]

SYDENSTRICKER, EDGAR. Health under the Social Security Act. *Social Service Review*, Vol. 10, pp. 12-22, 1936. [3 bibliographic footnotes.]

WIEHL, DOROTHY G. Measuring health needs in an urban district. II. Preventive health activities in relation to specific problems. *Milbank Memorial Fund Quarterly*, Vol. 14, pp. 144-162, 1936. [3 bibliographic footnotes.]

3. *Migration*

CLEATOR, P. E. Rockets Through Space. The Dawn of Interplanetary Travel. *New York* (Simon and Schuster), 1936. Pp. 227 + 15 plates. 8⅛ × 5½ inches. $2.50. [Bibliography of 24 titles.]

MALZBERG, BENJAMIN. Migration and mental disease among Negroes in New York State. *American Journal of Physical Anthropology*, Vol. 21, pp. 107-113, 1936. [Bibliography of 2 titles.]

MILLS, C. A. Dangers to southerners in northward migration. *American Journal of Tropical Medicine*, Vol. 15, No. 5, pp. (of reprint) 9, 1935. [Bibliography of 6 titles.]

MILLS, C. A. Dangers to southerners in northward migration. *Proceedings of the Central Society for Clinical Research*, October 27-28, 1933, p. (of reprint) 1.

SCHWARZ, ERNST. Probleme der mittelalterlichen deutschen Ostwanderung. *Zeitschrift für Rassenkunde*, Bd. 3, pp. 129-136, 1936. [Bibliographic footnotes.]

SPENGLER, JOSEPH J. Migration within the United States. *Journal of Heredity*, Vol. 27, pp. 1-20, 1936. [Bibliography of 23 titles.]

UNION OF SOUTH AFRICA. Statistics of Migration, 1934. [Volkstrekstatistiek, 1934]. *Pretoria* (Government Printer), 1935. Pp. xix + 66. 12¼ × 9½ inches. 2s. 6d. (paper). [In Dutch and English.]

4. *Population*

ALPATOV, W. W. and O. K. ROSSOLIMO. On the physiological properties of the individual at different stadiums of a growing and decaying protozoan population (*Paramecium caudatum*). *Bulletin Soc. Nat. Moscou, S. Biologique*, T. 44, pp. 293-301, 1935. [Bibliography of 7 titles.] [In Russian with English summary.]

BRUES, CHARLES T. Progressive change in the insect population of forests since the early Tertiary. *American Naturalist*, Vol. 67, pp. 385-406, 1933. [Bibliography of 20 titles.]

FRETS, G. P. Der Internationale Kongress für Bevölkerungswissenschaft in Berlin. *Psychiatrische en Neurologische Bladen, Jaarg.* 1936, No. 1, pp. (of reprint) 5.

ILLYEFALVI, LUDWIG I. Die Sozialen und Wirtschaftlichen Verhältnisse der bürgerlichen Bevölkerung in Budapest. *Budapest* (Bureau Communal de Statistique de Budapest), 1935. Pp. 1119. 10¼ × 7¼ inches. 20 Pengö. [In Magyar and German.]

NETHERLANDS INDIES. Census of 1930 in the Netherlands Indies. Volume V. Native Population in Borneo, Celebes, the Lesser Sunda Islands and the Moluccas. *Batavia* (Department van Economische Zaken), 1936. Pp. xiii + 239 + folding map. 13½ × 9½ inches. F. 7 (paper). [In Dutch and English.]

OETTEKING, BRUNO. Über die geschichtliche Entwicklung der indianischen Volksdichte. *Zeitschrift für Rassenkunde*, Bd. 3, pp. 171-176, 1936. [Bibliography of 10 titles.]

PEARL, RAYMOND. Multiplying man. *Yale Review*, The Spring, 1936, pp. 584-602.

RUSSELL, A. J. H., and K. C. K. E. RAJA. The population problem in India. *Indian Journal of Medical Research*, Vol. 23, pp. 545-568, 1935. [Bibliography of 23 titles.]

SPENGLER, JOSEPH J. Population growth, consumer demand and business profits. *Harvard Business Review*, January 1934, pp. 204-221. [Bibliographic footnotes.]

SPENGLER, JOSEPH J. Der Rückgang des Antimalthusianismus in Amerika des neunzehnten Jahrhunderts. *Weltwirtschaftliches Archiv*, Bd. 42, pp. 484-503, 1935.

5. *Mortality and General Vital Statistics*

DEPARTMENT OF COMMERCE, BUREAU OF THE CENSUS. Deaths (exclusive of stillbirths) from each cause, by sex, color or race, and age, in Continental United States: 1934. *Vital Statistics—Special Reports*, Vol. 1, No. 7, pp. 109-163, 1936.

DEPARTMENT OF COMMERCE, BUREAU OF THE CENSUS. Infants found dead. *Vital Statistics—Special Reports*, Vol. 1, No. 8, p. 165, 1936.

DEPARTMENT OF COMMERCE, BUREAU OF THE CENSUS. Births, deaths, infant mortality, and stillbirths: 1934. *Vital Statistics—Special Reports*, Vol. 1, No. 9, pp. 167-218, 1936.

DEPARTMENT OF COMMERCE, BUREAU OF THE CENSUS. Deaths from puerperal

causes in the United States and each state: 1934. *Vital Statistics—Special Reports*, Vol. 1, No. 10, pp. 219-222, 1936.

DEPARTMENT OF COMMERCE, BUREAU OF THE CENSUS. Deaths from puerperal causes in the United States and each state: 1934. *Vital Statistics—Special Reports*, Vol. 1, No. 11, p. 223, 1936.

DEPARTMENT OF COMMERCE, BUREAU OF THE CENSUS. Live births and deaths of infants in the United States and each state: 1933-1934. *Vital Statistics—Special Reports*, Vol. 1, No. 12, p. 225, 1936.

DEPARTMENT OF COMMERCE, BUREAU OF THE CENSUS. Live births and deaths of infants by color in the United States and each state: 1934. *Vital Statistics—Special Reports*, Vol. 1, No. 13, p. 227, 1936.

DEPARTMENT OF COMMERCE, BUREAU OF THE CENSUS. Deaths (exclusive of still-births) by color and age: 1934. *Vital Statistics—Special Reports*, Vol. 1, No. 14, pp. 229-239, 1936.

DEPARTMENT OF COMMERCE, BUREAU OF THE CENSUS. Deaths (exclusive of still-births) from selected causes, by age, in states and large cities: 1934. *Vital Statistics—Special Reports*, Vol. 1, No. 15, pp. 241-308, 1936.

DEPARTMENT OF COMMERCE, BUREAU OF THE CENSUS. Deaths (exclusive of still-births) from important causes, by certain subdivisions of the first year of life: 1934. *Vital Statistics—Special Reports*, Vol. 1, No. 16, pp. 309-345, 1936.

DEPARTMENT OF COMMERCE, BUREAU OF THE CENSUS. Deaths (exclusive of still-births) from selected causes, by month: 1934. *Vital Statistics—Special Reports*, Vol. 1, No. 17, pp. 347-369, 1936.

DUBLIN, LOUIS I. The Mortality from the Principal Cardiovascular Renal Diseases. A Study of the Experience Among the Industrial Policyholders of the Metropolitan Life Insurance Company 1911 to 1930. *Monograph 4 in a Twenty-Year Mortality Review. New York* (Metropolitan Life Insurance Co.), no date. 9¼ × 6⅛ inches. Pp. 80.

ELIOT, MARTHA M. Consumer demand for vital statistics. The need of the child hygienist. *American Journal of Public Health*, Vol. 26. pp. 493-496, 1936.

KAWAHITO, S. Observations of recent mortality statistics of Japanese in Manchuria. (Part III). *Journal of Oriental Medicine*, Vol. 24, pp. 109-130, 1936. [In Japanese with English summary.]

KAWAHITO, SADAO. Statistical study of the influence of meteorological condition upon mortality from various diseases in Manchoukuo. *Journal of Oriental Medicine*, Vol. 24, pp. 635-676, 1936. [In Japanese with English summary.]

LEAGUE OF NATIONS. Annuaire Statistique de la Société des Nations 1934/35. [Statistical Yearbook of the League of Nations]. *Geneva*, 1935. Pp. 314. 9¾ × 7½ inches. [In French and English.]

MILLS, C. A. Diabetes mellitus. Is climate a responsible factor in the etiology? *Archives of Internal Medicine*, Vol. 46, pp. 569-581, 1930. [Bibliography of 15 titles.]

MILLS, C. A. Diabetes mellitus. Sugar consumption in its etiology. *Archives of Internal Medicine*, Vol. 46, pp. 582-584, 1930. [Bibliography of 2 titles.]

MILLS, C. A. Geographic or climatic varitions in the death rate from pernicious anemia, exophthalmic goiter, Addison's disease and angina pectoris. *Archives of Internal Medicine*, Vol. 46, pp. 741-751, 1930.

MILLS, C. A. Suicides and homicides in their relation to weather changes. *American Journal of Psychiatry*, Vol. 91, pp. 669-677. [Bibliography of 2 titles.]

MILLS, C. A. Susceptibility to tuberculosis: Race or energy level? *American Journal of the Medical Sciences*, Vol. 189, pp. 330 ff., 1935. [Bibliography of 6 titles.]

MILLS, C. A., and CORDELIA OGLE. Climatic basis for susceptibility to heat stroke or exhaustion. *American Journal of Hygiene*, Vol. 17, pp. 686-696, 1932. [Bibliography of 3 titles.]

PALMER, CARROLL E. and WILLIAM M. GAFAFER. Selective mortality in childhood. *American Journal of Hygiene*, Vol. 21, pp. 608-612, 1935. [Bibliography of 8 titles.]

QUEBEC. Statistical Year Book. *Quebec*, 1935. Pp. xxxiii + 452. 9¾ × 6½ inches. [In French and English.]

REGISTRAR-GENERAL'S Decennial Supplement, England and Wales. 1931. Part I. Life Tables. *London* (His Majesty's Stationery Office), 1936. Pp. iii + 53. 13½ × 8¼ inches. 3 shillings net (paper).

6. *Morbidity and Epidemiology*

BERMAN, CHARLES. Malignant disease in the Bantu of Johannesburg and the Witwatersrand gold mines. *South African Journal of Medical Sciences*, Vol. 1, pp. 12-30, 1935. [Bibliography of 24 titles.]

COLLINS, SELWYN D. Age incidence of specific causes of illness. Based on records for 9,000 families in 18 states visited periodically for 12 months, 1928-1931. *Public Health Reports*, Vol. 50, pp. 1404-1427, 1935. [Bibliography of 14 titles.]

COLLINS, SELWYN D. Frequency of immunizing precedures of various kinds in 9,000 families observed for 12 months, 1928-1931. *American Journal of Public Health*, Vol. 25, pp. 1221-1225, 1935. [Bibliography of 8 titles.]

COLLINS, SELWYN D. The health of the worker. *Annals of the American Academy of Political and Social Science*, March 1936. Pp. 1-12. [Bibliographic footnotes.]

COLLINS, SELWYN D., and MARY GOVER. Age incidence of specific types of respiratory periods. *American Journal of Hygiene*, Vol. 21, pp. 613-627, 1935. [Bibliography of 9 titles.]

COLLINS, SELWYN D., and MARY GOVER. Influenza and pneumonia mortality in a group of about 95 cities in the United States during four minor epidemics, 1930-35, with a summary for 1920-35. *Public Health Reports*, Vol. 50, pp. 1668-1689, 1935. [Bibliography of 3 titles and a list of preceding papers on the epidemiology of influenza of 23 titles.]

GREENWOOD, M. A., BRADFORD HILL, W. W. C. TOPLEY and J. WILSON. Experimental Epidemiology. *Medical Research Council, Special Report Series*, No. 209. *London* (His Majesty's Stationery Office), 1936. Pp. 204 + 3 folding charts. 9⅝ × 6 inches. 3s. 6d. (paper). [Bibliography of 2½ pages.]

INTERNATIONAL LABOR OFFICE. Occupation and Health. Encyclopaedia of Hygiene, Pathology and Social Welfare. Vol I, A-H; Vol. II, I-Z.

Geneva, 1930 and 1934. Pp., Volume I, xxvi + 999; Volume II, vii + 1310. 10⅞ × 7¼ inches. £ 4; $22 (paper). $24 (cloth). (U. S. Agents: World Peace Foundation, 40 Mt. Vernon St., Boston). [Bibliography throughout.]

JÜRGENS, GEORG. Grundlagen der Epidemiologie. *Leipzig* (Johann Ambrosius Barth), 1936. Pp. ix + 165. 9¼ × 6¼ inches. RM 7.50 (paper).

LEAGUE OF NATIONS, HEALTH ORGANIZATION. Annual Epidemiological Report. Corrected Statistics of Notifiable Diseases for the Year 1934. *Geneva*, 1936. Pp. 114. 12½ × 9½ inches. 5 Swiss francs; $1.25 (paper).

MACDONALD, ELEANOR J. Fundamentals of epidemiology. *Radcliffe Quarterly*, February, 1936, pp. 19-22.

MALZBERG, BENJAMIN. Marital status in relation to the prevalence of mental diseases. *Psychiatric Quarterly*, Vol. 10, pp. 245-261, 1936. [Bibliography of 7 titles.]

MILLS, C. A. Climatic stimulation in relation to resistance to infection and general metabolic level. *Transactions of the American Clinical and Climatological Association*, 1934, pp. (of reprint) 16.

MILLS, C. A. Resistance to tuberculosis and energy level. *Revista Filipina de Medicina y Farmacia*, Vol. 26, No. 4, 1935, pp. (of reprint) 2.

NEUSTÄTTER, OTTO. Der Gesundheitsdienst der Lebensversicherung. Mit tabellarischer Übersicht über die Gesundheitsdienst-Einrichtungen der Gesellschaften in den verschiedenen Ländern. *Berlin-Schlachtensee* (Deutsche Zentrale für Gesundheitsdienst der Lebensversicherung), no date. Pp. 143 + 5 folding tables + 9 pp. on "Die Sterblichkeit der periodisch untersuchten Versicherten bei der Alten Leipzier Lebensversicherungsgesellschaft auf Gegenseitigkeit in Leipzig (Deutschland)" by Oskar Michels. 8½ × 5½ inches.

PERROTT, G. ST. J., and SELWYN D. COLLINS. Relation of sickness to income and income change in 10 surveyed communities. Health and Depression Studies No. 1. Methods of study and general results for each locality. *Public Health Reports*, Vol. 50, pp. 595-622, 1935. [Bibliographic footnotes.]

REINHARD, FERDINAND O., and W. THURBER FALES. Delinquent patients in venereal disease clinics. Results of a study in Baltimore City Health Department. *Journal of the American Medical Association*, Vol. 106, pp. 1377-1380, 1936.

SYDENSTRICKER, EDGAR and RALPH E. WHEELER. Whooping cough in surveyed communities. *American Journal of Public Health*, Vol. 26, pp. 576-585, 1936. [Bibliography of 9 titles.]

WHEELER, RALPH E. Epidemiology of whooping cough in a rural area. *Milbank Memorial Fund Quarterly*, Vol. 14, pp. 180-200, 1936. [Bibliographic footnotes.]

WILSON, E. B., and M. M. HILFERTY. On the explosiveness and destructiveness of the 1918 epidemic. *Proceedings of the National Academy of Sciences*, Vol, 22, pp. 120-122, 1936. [Bibliographic footnotes.]

YOSHIOKA, HIROTO. Studies on morbidity statistics based on case reports by medical practitioners (chiefly by women doctors). Third report. *Tokyo Joigakkai Zasshi*, Bd. 6, Ht. 1, pp. (of reprint) 86, 1936. [In English and Japanese.]

7. *Natality, Fecundity, Fertility*

HIMES, NORMAN E. The birth rate of families on relief: A summary of recent studies in the U. S. A. *Marriage Hygiene,* August 1935, pp. 59-63. [Bibliographic footnotes.]

KISER, CLYDE V. Recent trends in birth rates among foreign and native-white married women in up-state New York. *Milbank Memorial Fund Quarterly,* Vol. 14, pp. 173-179, 1936.

MILLS, C. A. Geographic variations in the female sexual functions. *American Journal of Hygiene,* Vol. 15, pp. 593-600, 1932. [Bibliography of 5 titles.]

MILLS, C. A. The influence of climate on the female sexual functions. *The Ohio State Medical Journal,* December 1931, pp. (of reprint) 6. [Bibliography of 5 titles.] [2 pages of discussion of paper by Henry John and E. R. Hayhurst.]

MILLS, C. A. and F. A. SENIOR. Does climate affect the human conception rate? *Archives of Internal Medicine,* Vol. 46, pp. 921-929, 1930. [Bibliography of 2 titles.]

PEARL, RAYMOND. Fertility and contraception in urban whites and negroes. *Science,* Vol. 83, pp. 503-506, 1936. [Bibliographic footnotes.]

8. *Birth Control*

HARTMAN, CARL G. Time of Ovulation in Women. A Study on the Fertile Period in the Menstrual Cycle. *Baltimore* (Williams and Wilkins Co.), 1936. Pp. x + 226. 7¾ × 5¼ inches. $3.00. [Bibliography of 16 pages.]

HIMES, NORMAN E. Medical History of Contraception. Medical Aspects of Human Fertility Series Issued by the National Committee on Maternal Health, Inc. Medical Foreword by Robert L. Dickinson. *Baltimore* (Williams and Wilkins Co.), 1936. Pp. xxxi + 521. 9¼ × 6½ inches. $7.00. [Bibliography of 60 pages.]

9. *Marriage and Divorce*

CHIDECKEL, MAURICE. The Single, the Engaged and the Married. With a Preface by T. Swann Harding and an Introduction by Benjamin S. Abeshouse. *New York* (Eugenics Publishing Co.), 1936. Pp. xxxiii + 270. 8 × 5⅜ inches. $2.50. [Bibliography of 10 titles.]

III. BEHAVIOR

1. *Racial and Genetic Psychology*

CURTI, MARGARET W., FRANCES B. MARSHALL and MORRIS STEGGERDA. The Gesell schedules applied to one, two, and three-year-old negro children of Jamaica, B. W. I. *Journal of Comparative Psychology,* Vol. 20, pp. 125-156, 1935. [Bibliography of 14 titles.]

WARDEN, CARL J., THOMAS N. JENKINS, and LUCIEN H. WARNER. Comparative Psychology. A Comprehensive Treatise. Vertebrates. *New York* (Ronald

Press Co.), 1936. Pp x + 560. 8⅜ × 5¾ inches. $4.50. [Bibliography of 2030 titles.]

WOLFE, JOHN B. Effectiveness of Token-Rewards for Chimpanzees. *Comparative Psychology Monographs*, Vol. 12, No. 5, Serial No. 60. *Baltimore* (Johns Hopkins Press), 1936. Pp. 72. 10 × 7 inches. $1.25. [12 bibliographical references.]

2. *Individual Psychology*

CHASSELL, CLARA F. The Relation Between Morality and Intellect. A Compendium of Evidence Contributed by Psychology, Criminology, and Sociology. *New York* (Teachers College, Columbia University), 1936. Pp. xviii + 556 + 1 folding chart. 9 × 6 inches. $4.50. [Bibliography of 13 pages.]

ELLIS, HAVELOCK. Psychology of Sex. A Manual for Students. *New York* (Emerson Books), 1935. Pp. xii + 377. 8½ × 5½ inches. $3.00. [Bibliography at the end of several chapters.]

HITSCHMANN, EDUARD and EDMUND BERGLER. Translated by Polly I. Weil. Frigidity in Women. Its Characteristics and Treatment. *Washington* (Nervous and Mental Disease Publishing Co), 1936. Pp. v + 76. 9 × 6 inches. $2.00. [Bibliographic footnotes.]

HOAGLAND, HUDSON. The physiological control of judgments of duration: evidence for a chemical clock. *Journal of General Psychology*, Vol. 9, pp. 267-287, 1933. [Bibliography of 33 titles.] [Summaries in French and German.]

HOAGLAND, HUDSON and LOUIS BERKOVICH. On the neurological basis of the localized response to irritants on the skin. *Journal of General Psychology*, Vol. 9, pp. 365-376, 1933. [Bibliography of 6 titles.] [Summaries in French and German.]

IOVETZ-TERESHCHENKO, N. M. Friendship-Love in Adolescence. *London* (George Allen and Unwin), 1936. Pp. xvi + 367. 8½ × 5½ inches. 16s. net.

KELLEY, TRUMAN L. Essential Traits of Mental Life. The Purposes and Principles Underlying the Selection and Measurement of Independent Factors, Together with Computational Tables. *Cambridge* (Harvard University Press), 1935. Pp. 145. 8½ × 5⅝ inches. $2.75. [Bibliography of 4½ pages.]

NICEFERO, ALFREDO. A proposito di psicogrammi dei delinquenti e sul metodo del "profilo grafico". *Giustizia penal Parte 1ª—I presupposti del diritto e della procedura penale*, Vol. 42, No. 3, pp. (of reprint) 11, 1936.

PRICE, HARRY. A Report on Two Experimental Fire-Walks. *Bulletin II. London* (University of London Council for Psychical Research, 1936. Pp. 15 + 20 plates. 9¼ × 6 inches. 5 shillings net (Foreign $1.25). (paper). [Bibliography of 3 pages.]

RUCKMICK, CHRISTIAN A. The Psychology of Feeling and Emotion. *New York* (McGraw-Hill Book Co.), 1936. Pp. xiii + 529. 9 × 6 inches. $4.50. [Bibliographic references throughout.]

SHERMAN, MANDEL, IRENE SHERMAN and CHARLES D. FLORY. Infant Behavior. *Comparative Psychology Monographs*, Vol. 12, No. 4, Serial No. 59. *Baltimore* (Johns Hopkins Press), 1936. Pp. 105. 10 × 7 inches. $1.50 (paper). [Bibliography of 39 titles.]

WEISENBURG, THEODORE, ANNE ROE and KATHARINE E. MCBRIDE. Adult Intelligence. A Psychological Study of Test Performances. *New York* (The Commonwealth Fund), 1936. Pp. xiii + 155 + folding table. $1.40. [Bibliography of 7½ pages.]

3. *Psychiatry*

FRY, CLEMENTS C. and HOWARD W. HAGGARD. The Anatomy of Personality. *New York* (Harper and Bros.), 1936. Pp. xi + 357 + 1 plate. 8 × 5 inches. $2.00.

PAGE, JAMES D. An experimental study of the day and night motility of normal and psychotic individuals. *Archives of Psychology*, No. 192, pp. 40, 1935. [Bibliography of 50 titles.]

ROSS, T. A. An Enquiry into Prognosis in the Neuroses. *Cambridge* (University Press); *New York* (Macmillan Co.), 1936. Pp. ix + 194. 8½ × 5½ inches. $3.00.

4. *History and Biography*

BRUES, CHARLES T. Charles Willison Johnson, 1863-1932. *Entomological News*, Vol. 44, pp. 113-116, 1933. [Portrait.]

CLINTON, G. P. Biographical memoir of Roland Thaxter. *National Academy of Sciences Biographical Memoirs*, Vol. 17, pp. 55-68, 1936. [Bibliography of 90 titles of R. Thaxter.] [Portrait.]

COBLENTZ, W. W. Biographical memoir of Edward Bennett Rosa 1861-1921. *National Academy of Sciences Biographical Memoirs*, Vol. 16, pp. 355-368, 1935. [Bibliography of 90 titles of E. B. Rosa.] [Portrait.]

CREW, HENRY. Biographical memoir of Thomas Corwin Mendenhall 1841-1924. *National Academy of Sciences Biographical Memoirs*, Vol. 16, pp. 331-351, 1935. [Bibliography of 4¼ pages of T. C. Mendenhall.] [Portrait.]

ENOCHS, ELISABETH S. Activities of the Federal Children's Bureau during 1935. *Americana Annual* for 1936, pp. (of reprint) 6. [List of "new publications".]

GREENWOOD, MAJOR. The Medical Dictator and Other Biographical Studies. *London* (Williams and Norgate), 1936. Pp. 213 + 6 portraits. 7¾ × 5¼ inches. 7s. 6d.

HIMES, NORMAN E. Jeremy Bentham and the genesis of English Neo-Malthusianism. *Economic History* (Supplement), Vol. 3, pp. 267-276, 1936. [Bibliographic footnotes.]

HOWARD, L. O. Biographical memoir of Edward Sylvester Morse 1838-1925. *National Academy of Sciences Biographical Memoirs*, Vol. 17, pp. 3-29, 1935. [Bibliography of 9½ pages of E. S. Morse.] [Portrait.]

HUXLEY, JULIAN. T. H. Huxley's Diary of the Voyage of H. M. S. Rattlesnake. Edited from the Unpublished Ms. *Garden City, N. Y.* (Doubleday, Doran and Co.), 1936. Pp. xiv + 301 + 13 plates. 9 × 6 inches. $3.00.

LACAPE, R. S. A la Recherche du Temps Vécu. *Actualités Scientifiques et Industrielles*, 288. *Exposés de Physiologie*, VIII. *Paris* (Hermann et Cie), 1935. Pp. 55. 10 × 6½ inches. 12 francs (paper).

LANE, ERNEST P. Biographical memoir of Ernest Julius Wilczynski 1876-1932. *National Academy of Sciences Biographical Memoirs*, Vol. 16, pp. 295-327, 1935. [Bibliography of 5 pages of E. J. Wilczynski; three pages of theses of students.] [Portrait.]

LINDGREN, WALDEMAR. Biographical memoir of George Perkins Merrill 1854-1929. *National Academy of Sciences Biographical Memoirs*, Vol. 17, pp. 33-53, 1935. [Bibliography of 11½ pages of G. P. Merrill.] [Portrait.]

MEINERS, CHRISTOPH. Die Verschiedenheiten der Menschennaturen (Ein Beitrag zur Geschichte der Rassenkunde). *Zeitschrift für Rassenkunde*, Bd. 3, pp. 313-315, 1936.

METHORST, H. W. L'organisation de la statistique aux Pays-Bas. *Revue internationale des Sciences administratives*, année 1936, No. 1, pp. (of reprint) 18.

MEYER, ARTHUR W. An Analysis of the *De Generatione Animalium* of William Harvey. *Stanford University, Calif.* (Stanford University Press), 1936. Pp. xx + 167 + 11 plates. 8 × 4⅞ inches. $3.00. [Bibliography of 8 pages.]

MILBANK MEMORIAL FUND. The Thirty-First Year in Review. Report for the Year Ended December 31, 1935. *New York*, 1936. Pp. 92. 9 × 6 inches.

PEARL, RAYMOND. Historical papers in the journal "Human Biology." *Isis*, Vol. 24, pp. 415-418, 1936.

ROSENDAHL, C. OTTO, Ross A. GORTNER and GEORGE O. BURR. J. Arthur Harris Botanist and Biometrician. *Minneapolis* (The University of Minnesota Press), 1936. Pp. viii + 209. 9¼ × 6 inches. $2.50. [Bibliography of 10½ pages.]

SARTON, GEORGE: Edited by, with the cooperation of R. C. ARCHIBALD, B. M. FRICK and A. POGO. Osiris. Vol. I. A Volume of Studies on the History of Mathematics and the History of Science. Presented to Professor David Eugene Smith on his 76th Birthday (Jan. 21, 1936). *Bruges* (Saint Catherine Press), 1936. Pp. 777. 10 × 7 inches (paper).

SPARGO, JOHN. The Legend of Hoover who "Did Nothing." *420 Lexington Ave., N. Y.* (Edgar Rickard), 1936. Pp. 39. 9 × 4 inches.

SPENGLER, J. J. Malthusianism and the debate on slavery. *South Atlantic Quarterly*, Vol. 34, pp. 170-189, 1935. [Bibliographic footnotes.]

SPENGLER, J. J. Malthusianism in eighteenth century America. *American Economic Review*, Vol. 25, pp. 691-707, 1935. [Bibliographic footnotes.]

UNITED STATES DEPARTMENT OF COMMERCE. Bureau of the Census. *Annual Report of the Secretary of Commerce*, 1935. Pp. 19-34.

VISHNEVSKI, B. N. Anthropology in U. S. S. R. in the course of 17 years (1917-1934). *American Journal of Physical Anthropology*, Vol. 21, No. 1, pp. 1-17, 1936. [Bibliography of 3½ pages.]

5. *Sociology, Law, Politics and Religion*

ALBRECHT, BOAS, BOHNSTEDT, BOSSE, BRENKE, BARON v. BROCKDORFF, COLM, GÜNTHER, HARMS, HEBERLE, HERMBERG, JAHN, JURKAT, KANELLOPOULOS, LÖWITH, MEINECKE, NICEFORO, v. REICHENAU, SCHMALENBACH, SORLEV, SOROKIN, STEINMETZ, STOLTENBERG, TAKATA, THURNWALD, WERNICKE, v.

WIESE, and WILBRANDT. Reine und Angewandte Soziologie. Eine Festgabe für Ferdinand Tönnies zu seinem achtzigsten Geburtstage am 26. Juli 1935. *Leipzig* (Hans Buske), 1936. Pp. 403 + 1 plate. 9¼ × 6¼ inches. 12.37 marks (paper). [20½ pages of Tönnies' publications.]

AMERICAN LIBERTY LEAGUE. Statement by National Lawyers Committee of the American Liberty League. Prepared pursuant to authorization given in conference in Washington, January 25, 1936, and made public by direction of the Administrative Committee of the League. *Document No.* 108. *Washington,* March 1936.

BAILEY, ALICE A. The Functions of the New Group of World Servers. *11 West 42nd St., New York;* 1935. Pp. 11. 8⅜ × 5¼ inches.

BELMONT, MRS. AUGUST. Facing the future. *International Conciliation,* No. 320, pp. 266-272, 1936.

BOWLER, ALIDA C. and RUTH S. BLOODGOOD. Institutional Treatment of Delinquent Boys. Part 2. A study of 751 Boys. *U.S. Department of Labor, Children's Bureau Publication* No. 230. *Washington* (U. S. Government Printing Office), 1936. Pp. v + 149. 9¼ × 6 inches. 15 cents (paper).

BUREAU OF THE CENSUS. Mortality Statistics, 1933. Thirty-fourth Annual Report. Rate Tables and General Tables for Continental United States with Supplemental Statistics for Hawaii, Puerto Rico, and the Virgin Islands. *Washington* (U. S. Government Printing Office), 1935. Pp. iv + 519. 11½ × 9¼ inches. $2.25.

CARNEGIE ENDOWMENT FOR INTERNATIONAL PEACE. Germany and Japan today. *International Conciliation,* No. 319. *New York,* 1936. Pp. 50. 7¾ × 5⅛ inches. 5 cents (paper).

CUNNINGHAM, BESS V. Family Behavior. A Study of Human Relations. *Philadelphia* (W. B. Saunders Co.), 1936. Pp. 471. 5¼ × 4 inches. $2.75. ["References" and "Additional Readings" at the end of each chapter.]

DESVERNINE, RAOUL E. The Need for Constitutional Growth by Constitution or Amendment. *Document* No. 119. *Washington* (American Liberty League), 1936. Pp. 21. 9 × 4 inches.

DESVERNINE, RAOUL E. Constitutional Heresy. *Document* No. 124. *Washington* (American Liberty League), 1936. Pp. 12. 9 × 4 inches.

FRANCE. The French Peace Plan. *International Conciliation,* No. 320, pp. 247-252, 1936.

HALL, FITZGERALD. A Federal Union—National and State Responsibilities. *Document* No. 123. *Washington* (American Liberty League), 1936. Pp. 20. 9 × 4 inches.

HALL, GLADYS M. Prostitution in the Modern World. A Survey and a Challenge. With an Introduction by Charles E. Raven. *New York* (Emerson Books), 1936. Pp. 200. 8⅜ × 5½ inches. $2.00. [Bibliography of 55 titles.]

HASTINGS, DANIEL I. The Liberty League—Old Friendships Destroyed. *Document* No. 122. *Washington* (American Liberty League), 1936. Pp. 20. 9 × 4 inches.

HOOVER, HERBERT. American Ideals versus The New Deal. 420 *Lexington Ave., New York* (Edgar Rickard) no date. Pp. 78. 8⅛ × 5½ inches.

HOOVER, HERBERT. The Choice for Youth. 420 *Lexington Ave., New York* (Edgar Rickard), 1936. Pp. 12. 9 × 4 inches.

HUDSON, MANLEY O. The Chaco arms embargo. *International Conciliation*, No. 320, pp. 217-246, 1936. [Bibliographic footnotes.]

LEIPER, HENRY S. The Church-State Struggle in Germany. A personal view based on two months' intimate contact with the situation in Europe during August and September, 1934. With a Preface by W. Stuart Macgowan. *"Friends of Europe" Publications* No. 21. *122 St. Stephen's House, Westminster, London* (Friends of Europe), 1936. Pp. 31. 8¼ × 5⅜ inches. 6 pence (paper).

MÉTAXA, J. N. Isolation. *International Conciliation*, No. 320, pp. 273-275, 1936.

NORRIS, J. FRANK. Sovietizing America Through Churches, Colleges, and Consumers' Cooperatives. *Rochester* (Interstate Evangelistic Association, Temple Bldg.), 1936. Pp. 64. 8¾ × 6 inches. 25 cents (paper).

OTIS, MERRILL E. It Can Be Done. *Document* No. 115. *Washington* (American Liberty League), 1936. Pp. 11. 9 × 4 inches. [Bibliographic footnotes.]

POPE, JAMES P. American foreign policy sound Democratic doctrine and sound Republican doctrine. *Congressional Record*, 1936. Pp. (of reprint) 1.

REED, JAMES A. Shall we Have Constitutional Liberty or Dictatorship? *Document* No. 120. *Washington* (American Liberty League), 1936. Pp. 15. 9 × 4 inches.

RICHARDSON, WILLIAM E. Insurance against war. *International Conciliation*, No. 320, pp. 253-265, 1936.

ROBERTS, STEPHEN H. The Squatting Age in Australia 1835-1847. *Melbourne* (Melbourne University Press), 1936. Pp. x + 455. 8½ × 5½ inches. 21s. [Bibliography of 6 pages.]

ROGERS, WILLIAM H. Should We Amend the Constitution to Grant the National Government General Welfare Powers? *Document* No. 113. *Washington* (American Liberty League), 1936. Pp. 34. 9 × 4 inches.

SCHRIEKE, B. Alien Americans. A Study of Race Relations. *New York* (The Viking Press), 1936. Pp. xi + 207. 8⅛ × 5½ inches. $2.50. [Bibliography of 7 pages.]

SHOUSE, JOUETT. The New Inquisition. *Document* No. 114. *Washington* (American Liberty League), 1936. Pp. 14. 9 × 4 inches.

SHOUSE, JOUETT. Abuses of Power. *Document* No. 118. *Washington* (American Liberty League), 1936. Pp. 11. 9 × 4 inches.

SHOUSE, JOUETT. An American Philosophy. *Document* No. 121. *Washington* (American Liberty League), 1936. Pp. 11. 9 × 4 inches.

VANDENBERG, ARTHUR H. A. Layman Looks at the Supreme Court. *Document* No. 116. *Washington* (American Liberty League), 1936. Pp. 11. 9 × 4 inches.

WALTON, EVERETT P. and PHILIP E. FOSS. Social Biology. A Textbook for Secondary Schools. *Phildelphia* (P. Blakiston's Son and Co.), 1936. Pp. xv + 537. 7⅞ × 5¼ inches. $1.68. [Bibliography of 68 titles.]

6. *Economics*

American Liberty League. The New AAA. A Measure Which Seeks to Circumvent the Recent Decision of the Supreme Court and Regardless of Constitutionality Permits Resumption of the Payment of Subsidies to Farmers. *Document* No. 110. *Washington*, 1936. Pp. 21. 9 × 4 inches.

American Liberty League. The President's 1936 Tax Proposals. The End of the So-called "Breathing Spell." *Document* No. 112. *Washington*, April 1936. Pp. 18. 9 × 4 inches.

American Liberty League. New Work-Relief Funds. An analysis of a situation demanding that Congress call a halt on departures from constitutional government, review policies initiated by the Executive but properly within the province of the Legislative Branch and cut short both waste and extravagance in the expenditure of public funds. *Document* No. 117. *Washington*, 1936. Pp. 20. 9 × 4 inches.

Ayres, Leonard P. Inflation. *The Cleveland Trust Co.* 1936, pp. 36. 9 × 6⅛ inches.

Cutten, George B. Entrenched Greed. *Document* No. 109. *Washington* (American Liberty League), 1936. Pp. 11. 9 × 4 inches.

Ecker, Frederick H. Administration of the Life Insurance Trusteeship. *New York* (Metropolitan Life Insurance Co.), 1936. Pp. 15. 9 × 4 inches.

Gebhart, John C. Federal Relief—What Next? *New York* (The National Economy League), 1936. Pp. iv + 27. 9 × 6 inches.

Retzer, Robert. The reserves of life insurance. We are told that they total some twenty billions of dollars. Do policy holders realize their equity in these reserves. *Baltimore*, May 1936, pp. (of reprint) 2.

Scanga, Giovanno. Orientamento Professionale. Bollettino d'Informazioni. Anno 1, N. 1; Anno 2, N. 2. *Rome* (Ministero Dell' Educazione Nazionale), 1935 and 1936. Pp. 27 each. 9¾ × 6⅞ inches.

Scoville, John W. Behavior of the Automobile Industry in Depression. *New York* (Chrysler Corporation), 1936. Pp. 31. 9 × 7 inches.

Shouse, Jouett. You Owe Thirty-One Billion Dollars. *Document* No. 125. *Washington* (American Liberty League), 1936. Pp. 10. 9 × 4 inches.

Silverherz, Joseph D. The Assessment of Real Property in the United States. *Special Report of the State Tax Commission*, No. 10. *Albany, N. Y.*, 1936. Pp. xxiii + 396. 9 × 5¾ inches. [Bibliography of 38 pages.]

Spengler, Joseph J. Have values a place in economics? *International Journal of Ethics*, Vol. 44, pp. 313-331, 1934. [Bibliographic footnotes.]

Stewart, Maxwell S. Income and Economic Progress. *Public Affairs Pamphlets* No. 1. *New York* (Pictorial Statistics), 1936. Pp. 34. 8½ × 5¼ inches. 10 cents (paper).

7. *Education*

Academy of Natural Sciences of Philadelphia. Frontiers. *Philadelphia*, 1936. Pp. 23. 10⅞ × 8½ inches.

CHESNEY, ALAN M., WORTH HALE, EDWARD S. THORPE, JR., with the assistance of CARROLL E. PALMER. Evaluation of the medical aptitude test. *Journal of the Association of American Medical Colleges*, pp. (of reprint) 20, January, 1936.

HOTCHKISS, WILLIAM O. The Future of Engineering Education. *Rensselaer Polytechnic Institute Bulletin*, Vol. 34, *Extra to* No. 4. *Troy, N. Y.*, 1936. Pp. 12. 8¼ × 6 inches.

8. *Ethnology, Cultural Anthropology, Travel and Exploration*

ARBUTHNOT, JOAN. More Profit Than Gold. *New York* (Charles Scribner's Sons), 1936. Pp. 287 + 12 plates. 8¼ × 5⅝ inches. $2.50.

CARRUTHERS, DOUGLAS. Arabian Adventure to the Great Nafud in Quest of the Oryx. *London* (H. F. and G. Witherby), 1935. Pp. xii + 208 + 33 plates and 2 maps. 8¾ × 5½ inches. 8s. 6d. net. [Bibliography of 5½ pages.]

HEINITZ, PROF. DR. Musik als rassenkundliches Forschungsmittel. *Zeitschrift für Rassenkunde*, Bd. 3, p. 199, 1936.

HERRMANN, ALBERT. Die blonden Serer und die türkischen Wu-sun. *Zeitschrift für Rassenkunde*, Bd. 3, pp. 200-201, 1936. [Bibliographic footnotes.]

HURLEY, VIC. Men in Sun Helmits. *New York* (E. P. Dutton and Co.), 1936. Pp. 252. 8⅛ × 5½ inches. $2.50.

KARL, F. Was sind die "Hoklo" von Fukien? *Zeitschrift für Rassenkunde*, Bd. 3, pp. 312-313, 1936.

LEAKEY, L. S. B. Kenya. Contrasts and Problems. *London* (Methuen and Co.), 1936. Pp. xiii + 189 + 8 plates. 7¼ × 5 inches. 7s. 6d.

MACMILLAN, W. M. Warning from the West Indies. A Tract for Africa and the Empire. *London* (Faber and Faber), 1936. Pp. 213 + 1 folding map. 8 × 5⅛ inches. 8s. 6d. [Bibliography of 2 pages.]

MALINOWSKI, BRONISLAW. Coral Gardens and Their Magic. A Study of the Methods of Tilling the Soil and of Agricultural Rites in the Trobriand Islands. Vol. 1, The Description of Gardening; Vol. 2, The Language of Magic and Gardening. *New York* (American Book Co.), 1935. Pp. Vol. 1, xxxv + 500 + 69 plates + two folding maps; Vol. 2, xxxii + 350. 9¼ × 6 inches. $8.00 per set.

PETERS, H. B. Haustierverbreitung als rassenhistorisches Indizium. *Zeitschrift für Rassenkunde*, Bd. 3, pp. 308-309, 1936.

PRICE, WESTON A. Eskimo and Indian field studies in Alaska and Canada. *Journal of the American Dental Association*, Vol. 23, pp. 417-437, 1936. [5 bibliographic footnotes.]

ROBINSON, WILLIAM A. Voyage to Galapagos. Illustrated by Daniel T. West. *New York* (Harcourt, Brace and Co.), 1936. Pp. viii + 279 + 8 plates. 8 × 5¼ inches. $3.00.

SAPPER, KARL. Akklimatisation und Rasse. *Zeitschrift für Rassenkunde*, Bd. 3, pp. 225-242, 1936. [23 bibliographic footnotes.]

SHAPIRO, HARRY L. The Heritage of the Bounty. The Story of Pitcairn Through Six Generations. *New York* (Simon and Schuster), 1936. Pp. xv + 329. 9 × 5⅞ inches. $3.00. [Bibliography of 15 titles.]

TAYLOR, GRIFFITH. Explorations in North West Papau. *Zeitschrift für Rassenkunde*, Bd. 3, p. 320, 1936.

VERHULPEN, EDMOND. Baluba et Balubaïsés du Katanga. Preface by Georges Van der Kerken. *Anvers* (L'Avenir Belge), 1936. Pp. 534 + viii + 2 folding maps. 10 × 6½ inches. 150 francs (paper), 180 francs (cloth) in Belgium 175 francs (paper), 210 francs (cloth) outside of Belgium. [Bibliography of 19 titles.]

WILLIAMS, JOSEPH J., S. J. Africa's God. I—Gold Coast and Its Hinterland. *Anthropological Series of the Boston College Graduate School*, Vol. I, No. 1. *Chestnut Hill, Mass.* (Boston College Press), 1936. Bd. 86. 9¾ × 6⅝ inches. $1.00 (paper). [Bibliography of 5 pages.]

WHITING, ALFRED F. Hopi Indian agriculture: I, Background. *Museum Notes* (*Museum of Northern Arizona*), Vol. 8, pp. 51-53, 1936.

IV. SOMATOLOGY AND CONSTITUTION

1. *Anatomy*

CORNELL UNIVERSITY MEDICAL COLLEGE. Studies from the Department of Anatomy, Vol. 16, 1934-35. *1300 York Ave., New York.* [Collection of reprints.]

DETWILER, SAMUEL R. Neuroembryology. An Experimental Study. *New York* (Macmillan Co.), 1936. Pp. x + 218. 8½ × 5¾ inches. $3.75. [Bibliography of 18 pages.]

EVANS, WILLIAM. The Course of the Oesophagus in Health, and in Disease of the Heart and Great Vessels. *Medical Research Council, Special Report Series*, No. 208. *London* (His Majesty's Stationery Office), 1936. Pp. 93. 9⅝ × 6⅛ inches. 2s. 6d. net (paper). [Bibliography of 34 titles.]

GROLLMAN, ARTHUR. The Adrenals. *Baltimore* (Williams and Wilkins Co.), 1936. Pp. xii + 410. 9 × 6 inches. $5.00. [Bibliography of 704 titles.]

HATT, PIERRE. Les Mouvements Morphogénétiques dans le Développement des Vertébrés. *Actualités Scientifiques et Industrielles*, 303. *Exposés de Biologie* (*Embryologie et Histogenèse*), V. *Paris* (Hermann et Cie), 1935. Pp. 57. 10 × 6½ inches. 12 francs (paper). [Bibliography of 2½ pages.]

KRAFKA, JOSEPH, JR. A Textbook of Histology. *Baltimore* (Williams and Wilkins Co.), 1936. Pp. vii + 246 + 1 plate. 9 × 6 inches. $2.50.

LOO, YÜ-TAO. The Cerebral Cortex of a Chinese Brain. (VI, VII). *Monographs of The National Research Institute of Psychology, Academia Sinica*, No. 8, November 1935. Pp. 81. 10½ × 7½ inches. [Bibliography of 18 titles.] [Summary in Chinese.]

LOO, YÜ-TAO. The Cerbral Cortex of a Chinese Brain. (VIII, IX, X). *Monographs of the National Research Institute of Psychology, Academia Sinica*, No. 9, November 1935. Pp. 35. 10½ × 7½ inches. [Bibliography of 24 titles.] [Summary in Chinese.]

MAINGARD, J. F. The anatomy of the European and Bantu parathyroid glands. *South African Journal of Medical Sciences*, Vol. 1, pp. 91-96, 1935. [Bibliography of 8 titles.]

MONTEIL, G. L'Oeuf. Essai de Théorie de sa Segmentation. *Paris* (G. Doin et Cie), 1936. Pp. 68 + 16 plates. 9 × 5½ inches. 18 francs (paper).

OKKELS, HAROLD. Les Parathyroïdes. *Actualités Scientifiques et Industrielles*, 307. *Histophysiologie*, I. *Paris* (Hermann et Cie), 1935. Pp. 26. 10 × 6½ inches. 10 francs (paper). [Bibliography of 28 titles.]

POLICARD, A. Six Conférences d'Histophysiologie Normale et Pathologique. Substance Osseuse. Ossification Endochrondrale. Alvéole Pulmonaire. Paroi Artérielle. Microincinération. Histospectographie. *Paris* (Masson et Cie), 1935. Pp. 105. 9¾ × 6⅝ inches. 15 francs (paper).

PRICE, WESTON A. Studies of relationships between nutritional deficiencies and (a) facial and dental arch deformities and (b) loss of immunity to dental caries among South Sea Islanders and Florida Indians. *Dental Cosmos*, November 1935, pp. 1033-1045. [Bibliography of 2 titles.]

PRYOR, JOSEPH W. Bilateral symmetry as seen in ossification. *American Journal of Anatomy*, Vol. 58, pp. 87-101, 1936.

SACHS, WULP. The vegetative nervous system in dementia praecox. *South African Journal of Medical Sciences*, Vol. 1, pp. 142-155, 1936. [Bibliography of 31 titles.]

SAUSER, GUSTAV. Eminentia colli femoris dorsalis. (Ein neuer osteologischer Befund am menschlichen Schenkelhals). *Zeitschrift für Rassenkunde*, Bd. 3, pp. 286-291, 1936. [Bibliography of 7 titles.]

SEGAL, M. Agenesis of the corpus callosum in man. *South African Journal of Medical Sciences*, Vol. 1, pp. 65-74, 1935. [Bibliography of 10 titles.]

STRAUS, WILLIAM L., JR. The thoracic and abdominal viscera of primates, with special reference to the orang-utan. *Proceedings of the American Philosophical Society*, Vol. 76, pp. 1-85, 1936. [Bibliography of 70 titles.]

WADDINGTON, C. H. How Animals Develop. *New York* (W. W. Norton and Co.), 1936. Pp. 128 + 7 plates. 8 × 5⅜ inches. $2.00.

WHITNALL, S. E. The Study of Anatomy. Written for the Medical Student. *Baltimore* (William Wood and Co.), 1936. Pp. viii + 113. 7¼ × 4⅞ inches. $1.75. [Bibliography of 10½ pages.]

WILLIAMS, JESSE F. Atlas of Human Anatomy with Explanatory Text. Colored illustrations by Franz Frohse, Max Brödel and Leon Schlossberg. *New York* (Barnes and Noble), 1935. Pp. 64. 8¼ × 5¼ inches. [Bibliography of 13 titles.]

WISLOCKI, GEORGE B. and LESTER S. KING. The permeability of the hypophysis and hypothalamus to vital dyes, with a study of the hypophyseal vascular supply. *American Journal of Anatomy*, Vol. 58, pp. 421-472, 1936. [Bibliography of 22 titles.]

2. *Physical Anthropology and Anthropometry*

EICKSTEDT, E. FRHR. Rassenuntersuchung Deutschlands. *Zeitschrift für Rassenkunde*, Bd. 3, pp. 162-171, 1936. [Bibliographic footnotes.]

HASEGAWA, TETSUICHIRO, HIROTO YOSHIOKA and KAZUKI HITOMI. Studies on the temperature of the students of medical school for women. *Tokyo Joigakkai Zasshi*, Bd. 6, Ht. 1, pp. (of reprint) 29, 1936. [In English and Japanese.]

JANUSCHKE, E. Primitivmerkmale in Zwischeneuropa—eine Nachwirkung der Brünnrasse? *Zeitschrift für Rassenkunde*, Bd. 3, pp. 269-285, 1936. [Bibliographic footnotes.]

KÄSSBACHER, MAX. Kraniometrische Untersuchung von Finnenschädeln. *Zeitschrift für Anatomie und Entwicklungsgeschichte*, Bd. 105, pp. 243-263, 1935. [1 bibliographic footnote.]

KENNEDY, WALTER P. and IAN MACKAY. Further studies on the polynuclear count in Iraq. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, Vol. 29, pp. 291-298, 1935. [Bibliography of 11 titles.]

KIRCHMAIR, HEINRICH. Daktylographische Rassenmerkmale im Ambimanuar. *Zeitschrift für Morphologie und Anthropologie*, Bd. 33, pp. 49-70, 1934. [Bibliography of 18 titles.]

KIRCHMAIR, HEINRICH. Daktylographische Geschlechtsunterschiede des Ambimanuars. *Zeitschrift für Morphologie und Anthropologie*, Bd. 33, pp. 440-463, 1935. [Bibliography of 31 titles.]

KIRCHMAIR, HEINRICH, and HEINRICH POLL. Zur Charakteristik des Rassenunterschiedes des Daktylogramms. Deltie, Strobotoxie und Brochie. *Biologia Generalis*, Bd. 12, pp. 202-216, 1936. [Bibliographic footnotes.]

KROGMAN, WILTON M. The cephalic type of the full-blood and mixed-blood Seminole Indians of Oklahoma. *Zeitschrift für Rassenkunde*, Bd. 2. pp. 176-190, 1936. [Bibliography of 14 titles.]

LESTER, P., and J. MILLOT. Les Races humaines. *Paris* (Armand Colin), 1936. Pp. 223. 6⅞ × 4¼ inches. 10.50 francs (paper), 12 francs (bound). [Bibliography of 45 titles.]

LUNDMAN, B. J. Ergebnisse einer Neukartierung von Beddoes Englandmaterial. *Zeitschrift für Rassenkunde*, Bd. 3, pp. 243-248, 1936. [Bibliography of 9 titles.]

PALMER, CARROLL E. Height and weight of children of the depression poor. *Public Health Reports*, Vol. 50, pp. 1107-1113, 1935. [Bibliography of 10 titles.]

PALMER, CARROLL E., and SELWYN D. COLLINS. Variations in physique and growth of children in different geographic regions of the United States. *Public Health Reports*, Vol. 50, pp. 335-347, 1935. [Bibliography of 9 titles.]

PEARL, RUTH D. A note on the relative areas of the nuchal and temporal surfaces with increase in cranial capacity. *Anthropologischer Anzeiger*, Jahrg. 12, pp. 284-292, 1935. [Bibliography of 1 title.]

POLL, HEINRICH. Dactylographische Geschlechtsunterschiede der Schizophrenen. *Monatsschrift für Psychiatrie und Neurologie*, Bd. 91, pp. 65-71 + 1 folding plate, 1935. [Bibliography of 9 titles.]

PRYOR, HELEN B. Width-Weight Tables. For Boys and Girls from 1 to 16 years. For Men and Women from 17 to 24 years. *Calif.* (Stanford University Press), 1936. Pp. 15. 8½ × 5½ inches. Single copy, 60 cents; 2-4 copies, 50 cents each; 5-9 copies, 40 cents each; 10 or more copies, 35 cents each. (paper).

PUCCIONI, NELLO. Beobachtungen bei den Badschuni (Somaliland). *Zeitschrift für Rassenkunde*, Bd. 3, pp. 136-141, 1936. [Bibliographic footnotes.]

SABATINI, ARTURO. Anthropologie der Tébu von Kufra. *Zeitschrift für Rassenkunde*, Bd. 3, pp. 253-269, 1936. [Bibliography of 24 titles.]

SCHWIDETZKY, L. Messbare Rassenunterschiede des Kinns. *Zeitschrift für Rassenkunde*, Bd. 3, pp. 309-310, 1936.

SELTZER, CARL C. The Racial Characteristics of Syrians and Armenians. Based upon data collected by W. B. Cline, C. S. Coon, J. M. Andrews and W. C. Dupertuis. *Papers of the Peabody Museum of American Archaeology and Ethnology, Harvard University*, Vol. 13, No. 3. *Cambridge*, 1936. Pp. vi + 77 + 1 plate. 9¼ × 6⅜ inches. $1.00 (paper). [Bibliography of 18 titles.]

SKERLJ, B. Nachwort zu den "Comments" von M. L. Tildesley. *Zeitschrift für Rassenkunde*, Bd. 3, pp. 319-320, 1936.

TALBOT, FRITZ B., EDWIN B. WILSON,, and JANE WORCESTER. Standards of basal metabolism of girls (new data) and their use in clinical practice. *Journal of Pediatrics*, Vol. 7, pp. 655 ff., 1935. [Bibliography of 12 titles.]

TILDESLEY, M. L. Comments on a recent study of the effects of physical culture upon women. *Zeitschrift für Rassenkunde*, Bd. 3, pp. 315-319, 1936.

VANZANT, FRANCES R., WALTER C. ALVAREZ, and JOSEPH BERKSON. The relation in man between gastric acidity and height and weight. *American Journal of Digestive Diseases and Nutrition*, Vol. 3, pp. 83-86, 1936. [Bibliography of 8 titles.]

WILSON, EDWIN B. Heights and weights of 275 public school girls for consecutive ages 7 to 16 years inclusive. *Proceedings of the National Academy of Sciences*, Vol. 21, pp. 633-634, 1935.

ŻEJMO-ŻEJMIS, STANISLAUS. Die Anthropologische Zusammensetzung Süddeutschlands. *Zeitschrift für Rassenkunde*, Bd. 3, pp. 141-155, 1936. [Bibliography of 26 titles.]

3. *Constitution*

BURCHARD, EDWARD M. L. Physique and Psychosis. An Analysis of the Postulated Relationship between Bodily Constitution and Mental Disease Syndrome. *Comparative Psychology Monographs*, Vol. 13, No. 1, Serial No. 61. *Baltimore* (Johns Hopkins Press), 1936. Pp. 73. 10 × 7 inches. $1.25 (paper). [Bibliography of 3½ pages.]

POLL, H. Ein wichtiger Fortschritt in der Methodik der Konstitutionsforschung. *Med. Klinik*, pp. (of reprint) 6, 1936. [Bibliography of 3 titles.]

RITALA, A. M. Über die Vererbung der Konstitution der Eltern auf das neugeborene Kind. Nebst Mitteilungen über die Resultate von Längen- und Gewichtsmessungen an Gebärerinnen. *Acta Societatis Medicorum Fennicæ "Duodecim,"* Ser. B. Tom. 23, Fasc. 1, pp. 1-61, 1935. [Bibliography of 4 pages.] [In Finnish with summaries in German and English.]

V. PHYSIOLOGY AND BIOCHEMISTRY

1. *Physiology*

ALVAREZ, WALTER C., FREDERICK PILCHER, MARY A. FOLEY, ANNETTE MAYER, and ARNOLD E. OSTERBERG. The effects on the gastric juice of man of six weeks'

deprivation of vitamin B. *American Journal of Digestive Diseases and Nutrition*, Vol. 3, pp. 102-107, 1936. [Bibliography of 22 titles.]

AUGER, DANIEL. Comparaison entre la Rythmicité des Courants d'Action Cellulaires chez les Végétaux and chez les Animaux. *Actualités Scientifiques et Industrielles*, 314. *Paris* (Hermann et Cie), 1936. Pp. 101. 10 × 6½ inches. 20 francs (paper). [Bibliography of 45 titles.]

BENOIT, JACQUES. Le Testicule. Organe Élaborateur de l'Hormone Sexuelle Mâle. *Actualités Scientifiques et Industrielles*, 259. *Exposés de Biologie. La Cellule Germinale dans l'Ontogenèse et l'Évolution*, III. *Paris* (Hermann et Cie), 1935. Pp. 64. 10 × 6¼ inches. 15 francs (paper). [Bibliography of 15 pages.]

BENOIT, JACQUES. L'Ovaire. Organe Élaborateur des Hormones Femelles. Les Hormones Sexuelles chez les Intersexués. *Actualités Scientifiques et Industrielles*, 260. *Exposés de Biologie. La Cellule Germinale dans l'Ontogenèse et l'Évolution*, IV. *Paris* (Hermann et Cie), 1935. 10 × 6½ inches. Pp. 68. 15 francs (paper). [Bibliography of 11 pages.]

BERNSTEIN, R. E., J. F. MAINGARD, and T. W. B. OSBORN. A note on the haemolytic complement in normal Europeans and Bantu. *South African Journal of Medical Sciences*, Vol. 1, pp. 63-64, 1935.

COOK, SHERBURNE F. Elementary Human Physiology. *New York* (Harper and Bros.), 1936. Pp. xi + 539 + 2 plates. 8½ × 5¾ inches. $3.50.

COOK, SHERBURNE F., and MARY A. BURMESTER. Laboratory Manual in Elementary Human Physiology. *New York* (Harper and Bros.), 1935. Pp. iii + 76. 8½ × 5½ inches. 50 cents (paper).

DUGGAR, BENJAMIN M., Edited by, with the Cooperation of JANET H. CLARK, KENNETH S. COLE, FARRINGTON DANIELS, GIOACCHINO FAILLA, CHARLES PACKARD, and HENRY W. POPP. Biological Effects of Radiation. Mechanism and Measurement of Radiation, Applications in Biology, Photochemical Reactions, Effects of Radiant Energy on Organisms and Organic Products. Volumes I and II. *New York* (McGraw-Hill Book Co.), 1936. Pp. xvii + 1343. 9 × 6 inches. $10.00. [Extensive bibliographies throughout.]

[EVANS, C. LOVATT.] Evans' Recent Advances in Physiology. Fifth Edition. Revised by W. H. Newton. *Philadelphia* (P. Blakiston's Son and Co.), 1936. Pp. xii + 500. 7⅞ × 5¼ inches. $5.00. [Bibliography at the end of each chapter.]

FISCHBORN, KARIN L. The effect of sudden alterations of temperature on the thyroid gland. *South African Journal of Medical Sciences*, Vol. 1, pp. 75-90, 1935. [Bibliography of 16 titles.]

HARDY, SIR WILLIAM BATE. Collected Scientific Papers of Sir William Bate Hardy, Fellow of the Royal Society, Fellow of Gonville and Caius College, Cambridge. Published under the auspices of the Colloid Committee of the Faraday Society. *Cambridge* (The University Press); *New York* (The Macmillan Co.), 1936. Pp. xi + 922 + 15 plates. 10¼ × 7⅛ inches. $18.00. [Bibliographies throughout.]

HOAGLAND, HUDSON. Temperature characteristics of the "Berger Rhythm" in man. *Science*, Vol. 83, pp. 84-85, 1936. [Bibliography of 5 titles.]

HOAGLAND, HUDSON, and CLIFTON T. PERKINS. Some temperature characteristics in man. *Journal of General Physiology*, Vol. 18, pp. 399-408, 1935. [Bibliography of 12 titles.]

JACOBS, M. H. Diffusion processes. *Ergebnisse der Biologie*, Vol. 12, pp. 1-160, 1935. [Bibliography of 16 pages.]

JACOBS, M. H. Permeability. *Annual Review of Biochemistry*, Vol. 4, pp. (of reprint) 16, 1935. [Bibliography of 63 titles.]

JAMES, H. E. O. Reports of the Committee upon the Physiology of Hearing. III —The Localisation of Sound. *Medical Research Council Special Report Series*, No. 207. *London* (His Majesty's Stationery Office), 1936. Pp. 38. 9⅝ × 6 inches. 9 pence net (paper). [Bibliography of 4 titles.]

KNIGHT, B. C. J. G. Bacterial Nutrition. Material for a Comparative Physiology of Bacteria. *Medical Research Council, Special Report Series*, No. 210. *London* (His Majesty's Stationery Office), 1936. Pp. 182. 9⅝ × 6 inches. 3s. net (paper). [Bibliography of 7 pages.]

LOUREIRO, J. A. DE. L'Ivresse (Physiologie de l'aliment excitant). *Actualités Scientifiques et Industrielles*, 265. *Paris* (Hermann et Cie), 1935. Pp. 38. 10 × 6½ inches. 10 francs (paper). [Bibliography of 47 titles.]

MACNIDER, WM. DE B. A study of the acquired resistance of fixed tissue cells morphologically altered through processes of repair. I. The liver injury induced by uranium nitrate. A consideration of the type of epithelial repair which imparts to the liver resistance against subsequent uranium intoxications. II. The resistance of liver epithelium altered morphologically as the result of an injury from uranium followed by repair, to the hepatoxic action of chloroform. III. The resistance to chloroform of a naturally acquired atypical type of liver epithelium occurring in senile animals. *Journal of Pharmacology and Experimental Therapeutics*, Vol. 56, pp. 359-387 + 17 plates, 1936. [Bibliography of 32 titles.]

MANTEGAZZA, PAOLO. Physiology of Love. Translated from the Italian by Herbert Alexander. Edited with an Introduction by Victor Robinson. *New York* (Eugenics Publishing Co.), 1936. Pp. xviii + 237. 9⅜ × 6¼ inches. $3.00.

MARETT, J. R. DE LA H. Environment, endocrines and race. *Zeitschrift für Rassenkunde*, Bd. 3, pp. 190-198, 1936. [Bibliography of 13 titles.]

MILLS, C. A. High external temperatures, the suprarenals, and body relaxation. *Transactions of the Central Society for Clinical Research, Journal American Medical Association*, Vol. 104, p. 251, 1935. [Discussion by E. P. McCullagh, E. L. Sevringhaus and C. F. G. Brown at end.]

MINZ, B. La Secretion de L'Adrenaline son Mécanisme Neuro-Humoral. *Actualités Scientifiques et Industrielles*, 273. *Exposés de Physiologie*, VI. *Paris* (Hermann et Cie), 1935. Pp. 47. 10 × 6½ inches. 12 francs (paper). [Bibliography of 4 pages.]

ORANJE, P., J. J. NORISKIN, and T. W. B. OSBORN. The effect of diet upon dental caries in the South African Bantu. *South African Journal of Medical Sciences*, Vol. 1, pp. 57-62, 1935.

OSTERBERG, ARNOLD E., FRANCES R. VANZANT, WALTER C. ALVAREZ, and ANDREW B. RIVERS. Studies of pepsin in human gastric juice. III. Physiologic

aspects. *American Journal of Digestive Diseases and Nutrition*, Vol. 3, pp. 35-41, 1936. [Bibliography of 5 titles.]

PETERS, JOHN P. Body Water. The Exchange of Fluids in Man. *Springfield, Ill.* (Charles C Thomas), 1935. Pp. ix + 405. 9 × 6 inches. $4.00 postpaid. [Bibliography of 875 titles.]

RAHN, OTTO. Invisible Radiations of Organisms. With an Introduction to the Physics of Radiation, by Sidney W. Barnes. *Berlin* (Gebrüder Borntraeger), 1936. Pp. x + 215. 8⅝ × 5¾ inches. 13.20 marks (paper). [Bibliography of 13 pages.]

2. *Senescence, Senility and Longevity*

KLUGER, JOSEF (Editor). Alters-Forschung. Untersuchungen und Berichte über Lebensdauer, Altern und Tod. 2 Jahrgang. *Wühschelburg-Heuscheuer*, (Josef Kluger), 1936. Pp. 40. 9¼ × 6⅝ inches. 3 marks (paper).

KOTSOVSKY, D. Altern und Reaktivierung in Vitro. (I. Mitteilung: Altern von Gummiarabikum). *Kolloid-Zeitschrift*, Bd. 74, pp. 88-90, 1936. [Bibliography of 28 titles.]

NEUSTÄTTER, OTTO, (Editor). Berichte über Gesundheitsdienst der Lebensversicherung. Zwanglose Hefte der Deutschen Zentrale für Gesundheitsdienst der Lebensversicherung E.V. *Berlin-Schlachtensee*, pp. 48. March, 1936.

WENSTRAND, D. E. W. Family history. Read at the Forty-sixth Annual Meeting of the Association of Life Insurance Medical Directors of America, October 17-18, 1935. *The Association of Life Insurance Medical Directors of America*, pp. (of reprint) 18, 1936.

WEZLER, K., and A BÖGER. Wachstum und Altern im Kreislauf. *Klinische Wochenschrift*, Jahrg. 15, pp. 257-260, 1936. [Bibliography of 27 titles.]

3. *Biochemistry*

ABDERHALDEN, EMIL, (Editor). Handbuch der biologischen Arbeitsmethoden. Lieferung 451. Fermentforschung. Containing following articles: Pektinfermente (Pektinasen), by Felix Ehrlich; Die Isolierung von kristallisiertem Trypsinogen und dessen Umwandlung in kristallisiertes Trypsin, by M. Kunitz and J. H. Northrop; Amylase (Nachtrag), by Theodor Sabalitschka; Vereinfachung der Methodik des Nachweises von Abwehrproteinasewirkungen (Nachtrag), by Emil Abderhalden. *Berlin* (Urban and Schwarzenberg), 1936. Pp. 206. 10 × 7 inches. 13 marks (paper). [Bibliographic references throughout.]

BOY, GERMAINE. L'énergie de croissance. XIV—Action des sels de zinc et de manganèse à concentrations toxiques sur les rendements énergétiques dans la germination. *Bulletin de la Société de Chimie biologique*, T. 17, pp. 1414-1426, 1935. [Bibliography of 10 titles.]

CLARK, JANET H. The denaturation of egg albumin by ultra-violet radiation. *Journal of General Physiology*, Vol. 19, pp. 199-210, 1935. [Bibliography of 11 titles.]

CLARK, JANET H. The effect of ultraviolet radiation on lens protein in the presence of salts and the relation of radiation to industrial and senile cataract. *Ameri-*

can Journal of Physiology, Vol. 113, pp. 538-547, 1935. [Bibliography of 6 titles.]

FIESER, L. F. The Chemistry of Natural Products Related to Phenenthrene. *New York* (Reinhold Publishing Co.), 1936. Pp. xii + 358. 9 × 6 inches. $6.50. [Bibliographic footnotes throughout.]

GRIGNARD, V., and PAUL BAUD, Published under the Direction of. Traité de Chimie Organique. Tome II. Fascicules I et II. Propriétés Optiques des Combinaisons Organiques, Structure des Molécules et Spectres d'Absorption. Spectres de Fluorescence. Applications des Rayons X à l'Étude des Composés Organiques. Effet Raman. Propriétés Diélectriques et Constitution Chimique. Propriétés Magnétiques et Constitution Chimique. Parachor et Constitution Chimique. Propriétés Organoleptiques et Constitution Chimique. Mécanisme des Réactions. Radicaux Libres Organiques. Transpositions Intromoléculaires. Empêchement Stérique. Catalyse. Antioxygènes et Prooxygènes, by P. Ramart-Lucas, A. Andant, M. Auméras, H. Bonnet, M. Bourguel, E. Carrière, E. Darmois, C. Dufraisse, A. Kirrmann, J. Lecomte, J. Martinet, C. Mauguin, P. Pascal, L. Piaux, G. Vavon. *Paris* (Masson et Cie), 1936. Pp. xv + 1273. 10 × 6½ inches. 250 francs for the two numbers. [Extensive bibliographies throughout.]

KLEIDERER, E. C. Optical rotation study of the new orally effective principle of ergot. *Journal of the American Chemical Society*, Vol. 57, p. 2007, 1935. [Bibliography of 2 titles.]

KRAHL, M. E., and G. H. A. CLOWES. Some effects of dinitrocresol on oxidation and fermentation. *Journal of Biological Chemistry*, Vol. III, pp. 355-369, 1935. [Bibliography of 25 titles.]

LANDSTEINER, KARL. The Specificity of Serological Reaction. *Springfield, Ill.* (Charles C Thomas), 1936. Pp. viii + 178. 9 × 5½ inches. $4.00 postpaid. [Bibliography of 8 pages.]

LAURESCO, CONSTANTIN. L'utilisation digestive des protéines et la richesse protéique de la ration. *Archives Internationales de Physiologie*, Vol. 42, pp. 145-158, 1935. [Bibliograhy of 3 titles.]

LAURESCO, CONSTANTIN. Influence de la cuisson sur la digestibilité des aliments protéiques. *Archives Internationales de Physiologie*, Vol. 42, pp. 159-168, 1935. [Bibliography of 13 titles.]

LAURESCO, CONSTANTIN. La puissance d'action protéolytique du suc pancréatique et de la succession trypsine-érepsine. *Archives Internationales de Physiologie*, Vol. 42, pp. 169-182, 1935. [Bibliography of 12 titles.]

LAURESCO, CONSTANTIN. La présence de l'ammoniaque dans les différentes portions du tractus gastro-intestinal. *Archives Internationales de Physiologie*, Vol. 42, pp. 183-191, 1935. [Bibliography of 6 titles.]

LAURESCO, CONSTANTIN. Les rôles respectifs des enzymes et des bactéries dans la formation de l'ammoniaque au cours des processus digestifs. *Archives Internationales de Physiologie*, Vol. 42, pp. 194-204, 1935. [Bibliography of 6 titles.]

LELU, PAULE. Les Parentés Chimiques des Êtres Vivants. *Actualités Scientifiques et Industrielles*, 282. *Exposés de Physiologie*, VII. *Paris* (Hermann et Cie), 1935. Pp. 47. 10 × 6½ inches. 10 francs (paper). [Bibliography of 30 titles.]

LELU, PAULE. Le métabolisme de l'imidazol. *Bulletin de la Société de Chimie biologique*, T. 17, pp. 637-655, 1935. [Bibliography of 11 titles.]

LUCK, JAMES M. (Editor). Annual Review of Biochemistry. Volume V. *Stanford University* (Ann. Rev. Bioch. Ltd.), 1936. Pp. ix + 640. 8¾ × 6 inches. $5.00. [Bibliography at end of each chapter.]

MOUROT, GILBERTE. La répartition des représentants du métabolisme azoté et sa signification physiologique. VII—L'évolution du métabolisme azoté endogène spécifique au cours du jeûne protéique. *Bulletin de la Société de Chimie biologique*, T. 17, pp. 1741-1789, 1935. [Bibliography of 29 titles.]

MOUROT, GILBERTE. Le dosage colorimétrique de l'allantoine. *Bulletin de la Société e Chimie biologique*, T. 17, pp. 1845-1850, 1935.

RAZAFIMAHERY, R. La dépense sulfurée endogène minima: grandeur, origine, caractères. *Annales de Physiologie et de Physicochimie biologique*, T. 11, pp. 261-300, 1935. [Bibliography of 27 titles.]

RAZAFIMAHERY, R. La physiologie du soufre dans le métabolisme protéique oxogène. *Annales de Physiologie et de Physicochimie biologique*, T. 11, pp. 327-353, 1935. [Bibliography of 11 titles.]

ROCHE, JEAN. Essai sur la Biochimie Générale et Comparée des Pigments Respiratoires. *Paris* (Masson et Cie), no date. Pp. 170. 10 × 6½ inches. 40 francs (paper). [Bibliography of 289 titles.]

TAUBER, HENRY. Experimental Enzyme Chemistry. *Minneapolis* (Burgess Publishing Co.), 1936. Pp. v + 118. 10¾ × 8½ inches. $3.50. [Bibliography of 18 titles.]

TERROINE, ÉMILE F., and CONSTANTIN LAURESCO. La libération de l'ammoniaque au cours des protéolyses enzymatiques. *Archives Internationales de Physiologie*, Vol. 42, pp. 205-222, 1935. [Bibliography of 13 titles.]

TERROINE, ÉMILE F., and R. RAZAFIMAHERY. Le métabolisme du soufre dans l'inanition. *Annales de Physiologie et de Physiochimie biologique*, T. 11, pp. 354-387, 1935. [Bibliography of 28 titles.]

THOMAS, PIERRE. Manuel de Biochimie. *Paris* (Masson et Cie), 1936. Pp. vi + 978. 10 × 6½ inches. 180 francs. [Bibliographies throughout.]

TIMMERMANS, JEAN. Les Solutions Concentrées. Théorie et Applications aux Mélanges Binaires de Composés Organiques. *Paris* (Masson et Cie), 1936. Pp. 645. 9¾ × 6½ inches. 130 francs (paper). [Bibliographies throughout.]

VALLA, SIMONE. La physiologie des lipides et des stérols dans l'inanition complète et l'inanition protéique. *Bulletin de la Société de Chimie biologique*, T. 17, pp. 1715-1740, 1935. [Bibliography of 17 titles.]

4. *Pharmacology*

CHEN, K. K., and A. LING CHEN. The alkaloid of chin-shih-hu. *Journal of Biological Chemistry*, Vol. 111, pp. 653-658, 1935. [Bibliography of 8 titles.]

DAVIS, M. EDWARD, FRED L. ADAIR, K. K. CHEN, and EDWARD E. SWANSON. The pharmacologic action of ergotocin, a new ergot principle. *Journal of Pharmacology and Experimental Therapeutics*, Vol. 54, pp. 398-407, 1935. [Bibliography of 11 titles.]

ECKLER, C. R., and H. A. SHONLE. A preliminary study of thio-arsene, disodium bis-(p-sulfophenyl) (acetamidophenyl)-dithio-arsenite. *American Journal of Syphilis and Neurology*, Vol. 4, p. 495 ff., 1935. [Bibliography of 9 titles.]

FABRE, RENÉ. Alcaloides (Première Partie). Généralités, Ptomaines et Leucomaines. Drogues a Alcaloides Liquides Toxiques. Opium et ses Alcaloides. *Actualités Scientifiques et Industrielles, 262. Leçons de Toxicologie* VII. *Paris* (Hermann et Cie), 1935. Pp. 65. 10 × 6¼ inches. 12 francs (paper).

FABRE, RENÉ. Alcaloides (Deuxième Partie) Des Solanées Mydriatiques, de la Coca, des Aconits, des Strychnées, Liliacées. Genalcaloides. *Actualités Scientifiques et Industrielles, 263. Leçons de Toxicologie,* VIII. *Paris* (Hermann et Cie), 1935. Pp. 59. 10 × 6½ inches. 12 francs (paper).

FABRE, RENÉ. Toxiques Minéraux (Première Partie). Généralités. Arsenic, Antomoine. *Actualités Scientifiques et Industrielles, 292, Leçons de Toxicologie,* IX. *Paris* (Hermann et Cie), 1935. Pp. 69. 10 × 6½ inches. 12 francs (paper).

FABRE, RENÉ. Toxiques Minéraux (Deuxième Partie). Mercure. Bismuth. Plomb. Thallium. *Actualités Scientifiques et Industrielles, 293. Leçons de Toxicologie,* X. *Paris* (Hermann et Cie), 1935. Pp. 57. 10 × 6½ inches. 12 francs (paper).

FABRE, RENÉ. Toxiques Minéraux (Troisième Partie). Cuivre. Zinc. Chrome. Nickel. Manganèse. Baryum. Radium. Métalloides Divers. *Actualités Scientifiques et Industrielles, 294. Leçons de Toxicologie,* XI. *Paris* (Hermann et Cie), Pp. 69. 10 × 6½ inches. 15 francs (paper).

KRAHL, M. E., and G. H. A. CLOWES. Action of dinitrocresol on yeast fermentation and oxidation. *Journal of the American Chemical Society*, Vol. 57, p. 1144, 1935.

MIDDLETON, WILLIAM S., and K. K. CHEN. Clinical results from oral administration of thevetin, a cardiac glucoside. *American Heart Journal*, Vol. 11, pp. 75 ff., 1936. [Bibliography of 13 titles.]

VI. PATHOLOGY, CLINICAL MEDICINE AND SURGERY

CHINESE MEDICAL JOURNAL Supplement No. 1. Pathology and Microbiology. Being Mainly Proceedings of the Chinese Society of Pathology and Microbiology held in Canton, November 5-8, 1935. *Peiping* (Chinese Medical Journal), 1936. Pp. 518 + 75 plates. 10 × 7 inches. $2.50 (paper).

DODGE, CARROLL W. Medical Mycology. Fungous Diseases of Man and Other Mammals. *St. Louis* (C. V. Mosby Co.), 1935. Pp. 900. 10 × 6¼ inches. $10.00. [Extensive bibliographies throughout.]

FIEBIGER, JOSEF. Die tierischen Parasiten der Haus- und Nutztiere, sowie des Menschen. Ein Lehr- und Handbuch mit Bestimmungstabellen für Tierärzte,

Ärzte und Studierende. Dritte, umgearbeitete Auflage. *Berlin* (Urban und Schwarzenberg), 1936. Pp. xii + 375. 10 × 7 inches. 17.50 marks (paper); 19 marks (cloth).

KERBY, GRACE. Survey of intestinal protozoa at autopsy. *Journal of Parasitology*, Vol. 21, pp. 449-450, 1935.

MALTZ, MAXWELL. New Faces—New Futures. Rebuilding Character with Plastic Surgery. *New York* (Richard R. Smith), 1936. Pp. xv + 315. 8½ × 5½ inches. $3.00. [Bibliography of 7 pages.]

PENNELL, VERNON. A Handbook of Urology for Students and Practitioners. *Cambridge* (University Press); *New York* (Macmillan Co.), 1936. Pp. viii + 224. 7¼ × 5 inches. $2.75.

PETTIT, AUGUST E. Sérothérapie Antipoliomyélitique d'Origine Animale (S.A.P.). Seize Années d'Expérimentation Clinique. *Paris* (Masson et Cie), 1936. Pp. 271. 10 × 6½ inches. 30 francs (paper). [Bibliography of 28 pages.]

VII. METHODOLOGY

1. *Mensurational and Observational*

[Vacant]

2. *Mathematical and Statistical*

BOND, W. N. Probability and Random Errors. *New York* (Longmans, Green and Co.), 1935. Pp. viii + 141. 8⅝ × 5⅜ inches. $3.75.

FLASKÄMPER, PAUL, and ADOLF BLIND, Editors. Contributions by BLIND, BURKHARDT, FLASKÄMPER, GERLOFF, GRÄVELL, HECHT, HENZEL, JÖRGES, LIND, LÜER, MEYER, MORGENROTH, MÜLLER, SCHÄFER, SEUTEMANN, VERSHOFEN, WINKLER, and ZAHN. Beiträge zur deutschen Statistik. Festgabe für Franz Žižek zur 60. Wiederkehr seines Geburtstages. *Leipzig* (Hans Buske), 1936. Pp. viii + 288. 9 × 6¼ inches. 9 marks (paper). [Bibliographic footnotes throughout.]

GOULDEN, C. H. Methods of Statistical Analysis. *Minneapolis* (Burgess Publishing Co.), 1936. Pp. ii + 165. 10¾ × 8½ inches. $3.00.

KULLBACK, S. A note on the distribution of a certain partial belonging coefficient. *Metron*, Vol. 12, pp. 65-70, 1935. [Bibliography of 4 titles.]

KULLBACK, SOLOMON. The distribution laws of the difference and quotient of variables independently distributed in Pearson Type III laws. *Annals of Mathematical Statistics*, Vol. 7, pp. 51-53, 1936. [Bibliography of 4 titles.]

REED, LOWELL J. Statistical treatment of biological problems in irradiation. *Biological Effects of Radiation*, pp. 227-251, 1936. [Bibliography of 10 titles.]

SCHWIDETZKY, I. Das Geltungsbereich des sog. "Typenfrequenzgesetzes." *Zeitschrift für Rassenkunde*, Bd. 3, pp. 156-161, 1936. [Bibliographic footnotes.]

TRELOAR, ALAN E. An Outline of Biometric Analysis. *Minneapolis* (Burgess Publishing Co.), 1936. Pp. [6] + 193. 10¾ × 8½ inches. $3.10.

3. *Other and General*

ANDREWS, JUSTIN, CARL M. JOHNSON, and SEYMOUR C. SCHWARTZ. The use of fecal extracts in the cultivation of *Endamoeba histolytica*. *The American Journal of Tropical Medicine*, Vol. 13, pp. 591-593, 1936. [Bibliography of 7 titles.]

ARKIN, HERBERT, and RAYMOND R. COLTON. Graphs. How to Make and Use Them. *New York* (Harper and Bros.), 1936. Pp. xvi + 224 + 1 plate. 9⅛ × 6⅛ inches. $3.00. [Bibliographic footnotes.]

DAVIS, WATSON. Microphotographic duplication in the service of science. *Science*, Vol. 83, pp. 402-404, 1936. [1 bibliographic reference.]

U. S. DEPARTMENT OF COMMERCE, BUREAU OF THE CENSUS. Instruction Manual. Procedure and Rules used in the Division of Vital Statistics for Coding Mortality and Natality Transcripts and Punching Machine Tabulation Cards. *Washington* 1936. Pp. 69. 10½ × 8 inches.

VIII. GENERAL AND MISCELLANEOUS

BAITSELL, GEORGE A. Manual of Biology. *New York* (Macmillan Co.), 1936. Pp. xi + 434. 8½ × 5⅝ inches. $2.50. [Bibliographies throughout.]

EICHLER, PHILIP. A Philosophy of Science. *New York* (G. P. Putnam's Sons), 1936. Pp. 111. 8 × 5½ inches. $1.50.

MACDONALD, J. RAMSAY, Lord President. Report of the Medical Research Council for the Year 1934-1935. Presented by the Lord President of the Council to Parliament by Command of His Majesty, January, 1936. *London* (His Majesty's Stationery Office), 1936. Pp. 183. 9¾ × 6 ⅛ inches. 3 shillings net (paper). [Bibliography with several chapters.]

ROBINSON, VICTOR [Editor]. A Comprehensive Encylopaedia-Dictionary of the Sexual Sciences. *New York* (Dingwall-Rock), 1936. Pp. xx + 819. 9⅜ × 6¼ inches. $7.50.

WOODRUFF, LORANDE L. Foundations of Biology. Fifth Edition. *New York* (Macmillan Co.), 1936. Pp. xiv + 583. 8½ × 5⅝ inches. $3.50. [Bibliography of 12 pages.]